1990 Illinois Dairy Report

Department of Animal Sciences
Cooperative Extension Service
Agricultural Experiment Station
College of Agriculture
University of Illinois at Urbana-Champaign

Making the Difference

1990 Illinois Dairy Days

January	8	Pekin, First United Methodist Church	January	12	Kankakee, Redwood Inn
	9	Dixon, Brandywine Inn		16	Quincy, Farm Bureau Building
	10	Freeport, Masonic Temple		17	St. Libory, American Legion Hall
	10	Elizabeth, Community Building		18	Breese, American Legion Hall
	11	Marengo, Clover Hoof Restaurant		19	Teutopolis, Knights of Columbus Hall

Authors

Department of Animal Sciences, University of Illinois at Urbana-Champaign, except as noted:

DAVID G. ATWELL, graduate student, nutrition
DAVID H. BAKER, professor and acting head, nutrition
LARRY L. BERGER, professor, nutrition
MARK G. CAMERON, graduate student, nutrition
JIMMY H. CLARK, professor, nutrition
CARL L. DAVIS, professor emeritus, nutrition
DEWAYNE E. DILL, assistant professor, extension
JAMES K. DRACKLEY, assistant professor, nutrition
PETER S. ERICKSON, graduate student, nutrition
GEORGE C. FAHEY, JR., professor, nutrition
DAVID B. FISCHER, agricultural adviser, Clinton County
WALTER L. HURLEY, associate professor, lactation physiology
MICHAEL F. HUTJENS, professor, extension
EDWIN H. JASTER, associate professor, management
JOANNE SICILIANO-JONES, graduate student, nutrition
TIM H. KLUSMEYER, graduate student, nutrition
MELVIN T. KUHN, graduate student, genetics
HARRIS A. LEWIN, associate professor, immunology
J. ROBERT LODGE, professor, reproductive physiology
GARY L. LYNCH, post doctorate, nutrition
STANISLAUS L. LUBUMBE, graduate student, management
ROBERT D. McCARTHY, graduate student, nutrition
GENE C. McCOY, dairy scientist, management
R. DAVID McQUEEN, professor, extension veterinarian, College of Veterinary Medicine
NEAL R. MERCHEN, associate professor, nutrition
MICHAEL R. MURPHY, associate professor, nutrition
DALE R. NELSON, professor, veterinary medicine, College of Veterinary Medicine
JAMES L. ROBINSON, professor, biochemistry
ROGER D. SHANKS, associate professor, genetics
STANLEY T. SMITH, area dairy adviser, Dixon
SID L. SPAHR, professor, management

Contents

1990 Theme: Making the Difference

University of Illinois Research Reports

The Department of Animal Sciences

David H. Baker

It is a pleasure for me to introduce the 1990 Illinois Dairy Report and welcome you to our Dairy Days Program. I wish to express appreciation to Mike Hutjens and Dewayne Dill for their efforts in organizing this important activity.

Construction of our new addition to Animal Sciences Laboratory is progressing smoothly and should be ready for occupancy in 1991. Dr. Dewayne E. Dill joined our faculty in February 1989 as an assistant professor of dairy cattle extension and research. Dewayne is a computer/supercomputer expert. He intends to use his expertise in this area to design systems that will aid dairy farmers in decision making. Bernie Heisner has recently been appointed as an adjunct assistant professor in the Department. Bernie will be assisting Dr. Spahr in training the dairy cattle judging team.

We appreciate your support and look forward to continued associations with you in the years ahead. Our goal continues to be excellence in all aspects of dairy cattle teaching, research and public service. Your suggestions and impressions of our activities are valued.

Dairy Faculty in the Department of Animal Sciences

Faculty	Specialization
Jimmy H. Clark, professor	Dairy cattle nutrition
Dewayne E. Dill, assistant professor	Extension dairy specialist
James K. Drackley, assistant professor	Ruminant nutrition
Charles N. Graves, associate professor	Reproductive physiology
Michael Grossman, professor	Dairy breeding and genetics
Walter L. Hurley, associate professor	Lactation endocrinology
Michael F. Hutjens, professor	Extension dairy specialist
Edwin H. Jaster, associate professor	Dairy cattle management
Bruce L. Larson, professor	Biochemistry & lactation
J. Robert Lodge, professor	Reproductive physiology
Gene C. McCoy, farm manager	Dairy cattle management
Roderick I. Mackie, professor	Ruminant microbiology
Michael R. Murphy, associate professor	Dairy cattle nutrition
James L. Robinson, professor	Biochemistry
Roger D. Shanks, associate professor	Dairy breeding & genetics
Sidney L. Spahr, professor	Dairy cattle management
Bryan A. White, assistant professor	Ruminant microbiology

Educational Opportunities for Students Interested in the Dairy Industry

J. Robert Lodge

Opportunities are still available for dairy students at the University of Illinois. Although changes have been made since the merger of the Department of Dairy Science and the Department of Animal Science into the Department of Animal Sciences in 1985 an excellent program is still available for students interested in dairy science.

The Department of Animal Sciences offers two options of study; a science and management option. The science option, as the name implies, requires more science courses and is designed to prepare students for entering professional or graduate schools. The management option contains seven specialties, one of which is dairy, and is designed for students interested in pursuing careers in the livestock and related industries. It emphasizes the disciplines involved in animal production and includes associated background courses for successful livestock careers.

All animal sciences students will take core courses in agriculture, chemistry, mathematics, communications, and biological sciences. All students are also required to take a minimum number of credits in social sciences and humanities. There is some flexibility in some of these areas in which courses are used for meeting the requirements. In animal sciences there are a few prescribed courses which include physiology, genetics, and nutrition. Those students with an interest in dairy would take courses in, principles of dairy production; comparative physiology of reproduction, lactation and growth; dairy herd management; genetics and animal improvement; and physiology of lactation. Additional agriculture elective courses will be taken to make a total of at least 40 hours which can include courses in agricultural economics, agronomy, or any other department in the College of Agriculture. The rest of the 126 hours required for graduation with a bachelor of science degree in agriculture can be open electives in any area of the students interest.

Each student will be assigned a faculty advisor who will assist the student in their choice of courses for each semester as well as to help students with academic or personal problems. Dairy students will be assigned an advisor with dairy interests, but if for any reason, at any time, a student wishes to change advisors it can be done very easily.

There are many activities on campus for students to participate in and usually a student will have to be selective in order not to spread too thin or grades suffer for lack of study time. These activities include many undergraduate student clubs, one of which is the Illini Dairy Club for students with an interest in dairy. This club is one of the most active in the college and has many projects throughout the year. They have monthly meetings during the academic year in which business is conducted and frequent speakers. The activities include social, judging contests, showmanship contests, publication of the Pipeline, cheese sale, speech contests, milk-a-cow booth and showing at the state fair to name a few. It gives students an opportunity to become involved with students having similar interest and to develop leadership skills. The club also participates in the student affiliate division of the American

Dairy Science Association both at the regional and national levels, competing both as a club and as individuals. A number of students have served as officers at these levels.

Dairy students can also participate on 4-H and collegiate judging teams where they have the opportunity to compete at regional and national contests.

Many students receive financial assistance toward the cost of their education through scholarships supplied by the college and the department. Several scholarships are specifically designed for dairy students. Many students work part time at the farms or in the laboratories which helps financially as well as students gaining experience and knowledge of dairy production and research.

All in all the University of Illinois, Department of Animal Sciences, offers an opportunity for an excellent education and training for students who are interested in the dairy industry.

For additional information write or call:

Department of Animal Sciences
University of Illinois
328 Mumford Hall
1301 W. Gregory Drive
Urbana, IL 61801
Phone: 217/333-1045

Managing and Maximizing Rumen Digestion

Michael F. Hutjens

Ruminants are unique animals that have a "dual" digestive system. The rumen microbes have the ability to digest forages (fibrous feeds), convert non-protein nitrogen (NPN) to high quality protein, and synthesize vitamins. The characteristics of rumen microbes, needs, and end-products are listed in Table 1. The second system consists of the lower digestive tract which is similar to the monogastic digestive system. An ideal dairy ration will optimize both systems to provide the correct amount and form of nutrients to support milk yield, growth, reproduction, and maintenance. This paper will explore the latest research and field applications to optimize rumen dynamics in high producing cows.

NITROGEN MANIPULATION

Meeting the dairy cow's protein needs is a complex challenge. An average 60 to 70 percent of dietary protein is degraded in the rumen and is called degradable intake protein (DIP). This breakdown is beneficial since it provides ammonia and carbon sources for microbial growth and is wasteful if excessive ammonia is produced (and must be excreted) and protein is used as energy resource. The high producing cow has an absolute requirement of amino acids. Three methods to increase amino acids include greater dry matter and protein intake, optimal rumen fermentation to synthesize microbial protein (60 to 120 grams of protein per pound digested organic matter), and increased level of UIP (undegraded intake protein). The following points should be evaluated.

1. Rumen microbials have a requirement for ammonia, isoacids (from protein degradation), amino acids, and short chain amino acids (peptides). A shortage of any nitrogen form will reduce rumen microbial growth.

2. Amino acids from UIP will vary in the type and amount. Corn based UIP will be low in lysine; alfalfa UIP can be low in methionine.

3. Animal and fish protein sources are rich in protein, essential amino acids, and UIP. Future protein supplements may contain these protein sources.

4. Heat-treating protein (soy and alfalfa) increased the amount of amino acids postruminally and decreases DIP.

5. High levels of rumen ammonia will raise blood or serum urea nitrogen which can reduce reproductive performance, waste protein, and increase energy needs to excrete excess ammonia as urea.

6. NPN (such as urea) may be needed if diets are low in DIP. Soluble protein should represent half of the DIP (30 to 35 percent of total nitrogen) and indicates a rapidly available source of ammonia-nitrogen.

FIBER NEEDS

Two fiber requirements are needed for optimum rumen function: fiber concentration and fiber length. Fiber is measured as acid detergent fiber (ADF) which equates to digestibility and neutral detergent fiber (NDF) which equates to fill and intake. Minimum ADF is 19 percent of the ration dry matter basis. NDF requirement is 1.2 percent of the cows body weight with 75 percent of the total provided by long forage or 28 to 30 percent of total ration dry matter.

Fiber length refers to the ruminating and chewing stimulation. Dairy cows require 550 to 600 minutes of total chewing time per day (eating and ruminating), 14 minutes of chew time per pound of dry matter consumed, or 5 pounds of long forage (over 1½ inch particle length). Wisconsin researchers reported that silage chopped at 3/16 inch theoretical length of cut (TLC) had 7 percent particles over 1½ inch, 10 percent over 1½ inch particles with ¼ inch TLC, and 15 percent over 1½ inch particles with 5/16 inch TLC. If silage is chopped too short, 5 to 7 pounds of baled hay are required.

NON FIBER CARBOHYDRATE

Carbohydrates comprise 70 to 80 percent to the total ration dry matter and consist of cell wall (fiber) and non-cell wall (starch and sugar). Several terms for non fiber carbohydrate (NFC) have appeared in the popular press including soluble carbohydrate, starch, and total non-structural carbohydrate or TNSC. NFC is a current area of research interest because it is 98 percent digestible, stimulates microbial growth, and can cause rumen acidosis if it is too high. Because NFC can not be analyzed in feed testing labs, the following formula has been used to calculate NFC.

$$NFC = 100 - (\text{crude protein} + NDF + \text{ash} + \text{fat})$$

The optimal dietary NFC is not well defined, but field observations suggest 35 to 40 percent of the ration dry matter, 20 pounds per day, or 1.1 percent of body weight. Several additional management considerations with NFC are listed.

1. Barley and wheat NFC is rapidly and extensively fermented in the rumen causing more risk of acidosis if not correctly fed.

2. The level of NFC varies greatly from 74 (shelled corn) to 47 (oats) to 8 (unlinted cottonseed).

3. Fermented, heat treated, or fine processed grain increases the rate of fermentation and solubilization of NFC in the rumen.

4. Pectin is a rumen digested carbohydrate found in alfalfa and beet pulp which can explain the success of these feed ingredients in dairy rations.

5. Rapidly fermented NFC should have a source of soluble nitrogen to optimize microbial growth.

STABILIZING RUMEN ACIDITY

The rumen pH should range from 6.2 to 6.8. Illinois researchers define rumen acidosis as the length of time the rumen pH is below 6. Low rumen pH results in a shift in rumen microbes (fewer fiber digesting bacteria), change in volatile fatty acid products (less acetate and more propionate), slower rate of passage (reduced feed intake potential), and a slowed microbial metabolism (less growth and production of end products). Dairy farmers can "manage" rumen pH with the following factors.

1. Total mixed rations (TMR) will provide a constant and balanced flow of nutrients for rumen fermentation.

2. Feeding grain several times avoids pH drops below 6.

3. The maximum amount of grain should be limited to 5 pounds of dry matter per meal.

4. Electronic computer grain feeders will manage grain intake and patterns.

5. Balancing NFC with ADF and adequate functional fiber can stabilize rumen pH.

6. Ration moisture should not exceed 50 percent.

7. Feeding 2 to 4 pounds of forage dry matter prior to grain consumption can provide natural buffer.

RUMEN FEED ADDITIVES

Rumen buffer (sodium bicarbonate) increased milk yield by 2.2 pounds of 3.5 percent fat-corrected milk (based on 24 research studies with 2087 cows). Buffers can increase dry matter intake and stabilize rumen pH above 6 with the optimal response in early lactation cows (fresh less than 100 days). The following products can be used.

1. Sodium bicarbonate is an effective buffer fed at the rate of .25 to .5 pounds per day.

2. Sodium sesquicarbonate is a buffer and alkalinizing agent fed at the rate of .25 to .5 pounds per day.

3. Magnesium oxide is an alkalinizing agent and source of magnesium fed at .1 to .2 pound per day.

Sodium bentonite is not a buffer, but can change the rate of passage and improve ion exchange capacity in the rumen. Limestone (calcium carbonate) does not have buffering effect in the rumen. Potassium carbonate can be used as a buffer, but it is more expensive per pound than sodium bicarbonate and requires .6 to .9 pounds per cow per day.

Yeast and yeast cultures can improve the rumen environment by stimulating fiber digesting bacteria, reducing lactate production, and maintain higher rumen pH. A reduction of rumen methane and ammonia can improve rumen efficiency. Rations with higher levels of soluble NFC (50 percent grain) provided the greater response in milk yield.

Methionine and methionine hydroxy analog have varied milk production responses with protozoa numbers increased in one study. Minnesota workers suggest feeding 20 grams of methionine or 30 grams of analog can improve fat test in high grain diets.

Isoacids (isobutyrate, isovalerate, 2-methylbutyrate, and n-valerate) are required by fiber digesting bacteria. Degradation of protein and synthesis in the rumen normally provide the isoacids for bacteria needs. Some diets could limit isoacid synthesis and a response to added isoacids could occur. Field acceptance and research results with commercially produced isoacids were variable and are not widely used.

Probiotics are relatively new areas of research and field use. These products are primarily microbial cultures or fermentation products added to the ration to balance or replace unfavorable organisms. Antibiotics destroy organisms; probiotics compete. Probiotics have been fed to cattle under stress conditions such as in off-feed situations, acidosis, early lactation, and scouring animals. A wide variety of commercially available organisms are available in pure culture or a combination (National Feed Ingredient Association listed 15 strains in 1982). These products are live organisms and must be handled to maintain viability. Research results should be reviewed to determine product success and farm conditions assessed prior to supplementation.

Fungal additives contain enzymes that can digest and cleave lignocellulose bonds (fiber). Improvements in fiber breakdown and protein synthesis in the rumen has been reported from feeding fungal extracts. Milk production responses (3.1 pounds of milk) and reduced heat stress (decreased rectal temperature and respiratory rate) have been reported.

EFFECTS OF FEEDING FAT

Unprotected fat (forage and grain oil, oilseeds, oils, or animal fats) should be limited to a total of 5 percent of the total ration dry matter or 3 percent added unprotected fat. These fats affect rumen fermentation by absorption on the bacteria and coating of feed particles decreasing digestibility. Unsaturated fatty acids (found in vegetable and fish oils) have greater toxicity than hard fats (animal). Protected fats (such as prilled fats and calcium salts) do not affect rumen fermentation and can be fed at higher levels.

BUILDING RATIONS

Three factors to build rations for high producing cows to optimize rumen dynamics are balancing for key nutrients (Table 2), evaluating feed nutrient composition (Table 3), and selecting compatible feeds (Table 4). Other key considerations include forage quality, feed inventory, and costs.

Table 1. Characteristics of rumen microbes (adapted from Chase and Sniffin, 1987)

Class	Substrate	Products	pH	Time to double
Fiber bacteria	Cellulose Hemicellulose Isoacids Ammonia	Acetate Other VFA	Neutral	8-10 hours
NFC bacteria	Starch Sugars Amino acids Ammonia	Propionate Other VFA	Acidic	1/4-2 hours
Protozoa	Starch Sugars Bacteria Amino acids	VFA	Neutral	15-24 hours

Table 2. Nutrient guidelines for high producing dairy cows (adapted from Sniffin and Chase, 1988 and NRC, 1988).

	Stage of Lactation		
	Early	Mid	Late
Dry matter intake (lb)	52	49	42
Protein (% DM)	18	16	14
(% soluble)	30	32	34
(% DIP)	60	64	68
(% UIP)	40	36	32
ADF (% DM)	19	21	24
NDF (% DM)	28	32	36
NFC (% DM)	40	37	34
Fat (% DM)	7	5	3

Table 3. Composition of typical Illinois feeds (adapted from Sniffin and Chase, 1988).

	D.M.		Protein			Carbohydrate		
Forage	(%)	CP	DIP	UIP	SOL	ADF	NDF	NFC
Alfalfa	90	22	72	28	20	30	40	25
	60	22	80	20	45	30	40	25
	30	22	90	10	60	30	40	25
	90	17	72	28	20	34	47	23
Corn silage	35	8	73	27	50	24	45	39
Grass	90	14	63	37	20	38	67	9
Concentrates								
Barley	90	12	79	21	35	7	19	55
Beet pulp	90	10	70	30	4	34	54	30
Bloodmeal	90	80	18	82	9	NA	NA	NA
Brewers grain	90	29	47	53	3	23	46	13
Corn, ear	87	9	35	65	16	11	23	59
Corn, distillers	90	30	38	62	15	16	42	12
Corn, gluten feed	92	21	70	30	48	15	41	27
Corn, shelled	87	11	35	65	12	3	9	74
	72	11	65	35	40	3	9	74
Cottonseed, whole	92	24	55	45	33	29	44	8
Oats	90	13	80	20	31	15	32	47
Soybeans, raw	90	42	80	20	40	10	16	33
heated	93	42	52	48	17	10	16	33
Soybean meal	90	49	72	28	20	9	15	27
Urea	93	282	100	0	100	0	0	0

Table 4. Examples of feed selection for rumen compatability (adapted from Parker, 1988)

	Forage	Grain	Protein Supplement
1.	High sol protein	Rapid NFC	Low sol protein (UIP)
	Alfalfa silage	Barley	Distillers grain
	Lush pasture	H.M. shelled corn	Brewers grain
	Excellent alfalfa hay	Wheat	Heated soybeans
2.	Moderate sol protein	Variable NFC	Moderate sol protein
	Mixed hay	Dry corn	Soybean meal
	Haylage/corn silage	H.M. ear corn	Whole cottonseed
	Average alfalfa hay	Oats	Linseed meal
3.	Low sol protein	Slow NFC	Higher DIP
	Grass hay	Beet pulp	Corn gluten feed
	Corn silage	Dried ear corn	Raw soybeans
		Dry grains	Urea

Energy Management of Forages

Stanley T. Smith and David B. Fischer

Forages are the foundation of dairy rations. Forages make up 40 to 60 percent of milking rations and nearly 100 percent of dry cow and older heifer rations. The remaining diet consists of grains and other feedstuffs used to compliment the nutrient deficiencies in the forage. Therefore, in order to achieve high milk production at the lowest possible cost, top quantity and quality forage production is a must.

Since Illinois dairymen produce the majority of their dairy forage needs, it is important to take a close look at managing the energy inputs necessary for profitable production. In addition to the importance in the dairy cow's diet, forages play a fasinating role in modern agronomic practices. Alfalfa, for example, provides nitrogen to the soil, creates a means of reducing soil erosion, improves soil tilth, and can be very competitive in net return per acre when compared to cash grain crops.

Alfalfa is considered the "queen of forages" and has the potential to produce more protein per acre than any other commonly grown forage or grain crop. In order to achieve that potential in an economic way it is necessary to evaluate the cost per ton of a quality product. When converted to dollars and cents, alfalfa is a very valuable crop. So it deserves proper establishment and management to produce a high return per dollar invested. To obtain the goal of high annual yields and a longevity of four to five years there are ten steps to consider when producing alfalfa.

1. Select a well drained field for establishment. Alfalfa does best on a field rotated out of alfalfa for at least one year because of the autotoxicity effect of a previous alfalfa crop.

2. Soil test and correct the pH needs at least six months before establishment. Lime the field to a pH of 6.8 to 7.0 Fertilize according to your soil tests. On silt loam soils apply enough fertilizer to bring P_1 test up to 60 and K test up to 400 if possible. Higher values are generally not practical and additional fertilizer should be topdressed according to the annual removal rate of the hay crop. Boron and sulfer should be applied after the alfalfa crop has been established and then based on soil needs.

3. Select good quality seed of a high yielding, disease resistant variety that is adopted to your area of the state. Be aware that the low cost varieties may not provide the longevity of stand needed for optimum profitability.

4. Prepare a fine, firm seedbed that is relatively weed free. The firmness provides good soil to seed contact and helps bring soil moisture to the germinating seeds.

5. A seeding rate of 18 pounds of inoculated seed per acre is suggested for direct seeding. When seeding with a companion crop 14 pounds may be satisfactory. Use a roller type seeder which compacts the soil and seed for excellent soil-seed contact.

6. The seeding date will depend on your location in the state and preference between late summer and spring seeding. A late summer or early fall seeding should be planted at least seven to eight weeks before the average date of a killing frost. This will allow the plant to store enough nutrients in the roots to survive the winter. Spring seedings should be done in early April for the lower 2/3 of Illinois and from April 10 to 15 for the northern 1/3 of the state. Later spring seedings up to mid-May may be acceptable but with increased chances of grassy weed problems and less change for adequate rainfall.

7. Pest control meaures may be needed for grass and broadleaf weed control as well as insects and diseases. Assess the pest problems according to economic threshholds and follow safe application practices of any chemicals. Alfalfa weevil and potato leafhopper are the two major insects that usually require control measures.

8. Harvest the first cutting at late bud to first flower stage and each 30 to 35 days thereafter. This schedule would allow 4 to 5 cuttings in Southern Illinois and 3 to 4 cuttings in Northern Illinois depending on the weather. Take the last harvest no later than 35 days before the average killing frost to allow for sufficient replenishing of plant root reserves for overwintering. Table 1 illustrates the value of early cut, high quality alfalfa in the milking ration. Regardless of the level of concentrate feeding, the pre-bloom hay will support more milk production than the other stages of harvest.

9. Fertilize for quantity based on soil productivity and actual hay removal. It doesn't pay to apply more fertilizer than the soil is capable of producing. Inventory the hay removal and replace phosphorus and potassium at the rate of 12 to 15 pounds of P_2O_5 and 60 pounds of K_2O per ton of hay removed from the field. This topdress fertilizer should be applied in split applications during the growing season. Boron and sulfer needs should be applied at this time.

10. Taking a final harvest soon after a killing frost will not hurt the alfalfa stand. The key word is "killing frost" which can be identified as 24° to 26° F or below. A light frost does not put the plant into dormancy thus as the plant regrows it pulls out the carbohydrate reserves needed for winter survival and spring growth. Leave a 3 to 5 inch stubble which helps catch snow and insulate the crowns from winter temperatures.

COST OF PRODUCTION

The cost of establishing and maintaining a direct alfalfa seeding can be costly so it is important to manage it as agressively as any other crop or enterprise. Cutting back on inputs may result in reduced tonnage and a decrease in the life of the stand.

Maximum tonnage per acre is needed to make the best use of the energy required to produce a ton of hay. Table 2 gives a breakdown of estimated costs per acre to grow, harvest and store alfalfa hay. In order to make the best use of the energy costs it is necessary to spread those costs over increased tonnage per acre. How many tons of dry hay are produced per acre annually? To optimize the profit potential of the crop it is necessary for the producer to be able to answer that question accurately. The amount of replacement fertilizer needed is directly correlated to hay removal. Keep this in mind during a drought year or an extremely good growing year. Maintenance levels for fertility probably will not be the same for each field or each year.

A simple pocket notebook used to record the field location, harvest date and tons removed will provide an inventory that can save energy dollars spent on over fertilizing. Or increase the yield profits by fertilizing the right fields that will respond to added fertility. This same inventory record could also include feed quality information and storage location that will be beneficial in planning the years' feeding program and the need for extra forage purchases or availability of excess hay to sell.

Another energy consideration is the harvesting equipment options available to producers. The cost of harvesting and storing the alfalfa crop shown in Table 3, compares the costs of square bales versus round bales. Personal preference of the producer, the ability to handle and feed the various size bales, and other factors will also play a role in the decision on the type of harvesting equipment used.

SUMMARY

The ability to properly manage the energy requirements needed for optimum forage production will result in increased net income for the producer. It is important to monitor the productivity of the forage enterprise. This includes knowing the soil productivity capabilities, fertility useage, best management practices, feed value of crop at various harvesting stages, and the annual crop removal rate per acre. The bottom line is to evaluate the cost effectiveness of all expenditures inorder to make sound management decisions.

(Support for the printing of this article was provided by the Illinois Department of Energy and Natural Resources)

Table 1 Yield of 4% Fat Corrected Milk (FCM) in pounds per day from four alfalfa hays fed at four concentrate levels.

% Conc. in Diet DM Basis	Alfalfa Maturity (Bloom) Pre	Early	Mid	Full	Avg.
20	79.6	68.0	57.2	52.1	64.2
37	83.2	69.1	62.5	55.4	67.5
54	87.1	77.2	64.7	69.5	73.8
71	86.0	77.2	64.7	69.5	74.3
Avg.	84.0	72.9	62.6	60.4	

SOURCE: Kawas et al. Suppl. 1 to J. Dairy Sci. 6:181-198

Table 2. ESTIMATED COSTS PER ACRE TO GROW, HARVEST, AND STORE FOUR CUTTING ALFALFA HAY IN SQUARE BALES

Tons Harvested yield,90% D.M.	3.00	4.50	6.00	9.00
Seeding Establishment and Maintenance (4 years)				
Land charge[1]	$60.00	$60.00	$60.00	$60.00
1/4 of seed	8.50	10.00	11.50	13.00
Lime, P&K fertilizer removals	26.00	36.00	48.50	67.00
Chemicals and sprays	8.00	10.00	12.00	14.00
Machinery costs	11.00	12.00	13.00	14.00
Labor @ $6.00/hr	4.00	4.50	5.00	5.50
Interest on operating capital	3.40	4.30	5.40	6.80
Management and overhead[2]	4.20	5.30	6.70	8.40
TOTAL PER ACRE	$125.10	$142.10	$162.10	$188.70
TOTAL PER TON HARVESTED	$ 41.70	$ 31.58	$ 27.02	$ 20.97
Harvesting and Storing Costs				
Square bales - low mechanization				
Mow, condition, rake	$35.40	$35.40	$37.20	$39.00
Baling	33.50	36.50	39.50	42.50
Wagons, etc	10.80	16.20	21.60	32.40
Labor @ $6.00/hr	36.00	45.00	54.00	72.00
Management and overhead[2]	8.00	9.30	10.50	13.00
TOTAL PER ACRE	$123.70	$142.40	$162.80	$198.90
TOTAL PER TON HARVESTED	$ 41.23	$ 31.65	$ 27.13	$ 22.10
Storage Costs				
Buildings	$12.00	$18.00	$24.00	$36.00
Interest on hay (12% for 6 mo.)	10.80	16.20	21.60	32.40
Management and overhead[2]	1.60	2.40	3.20	4.80
TOTAL PER ACRE	$24.40	$36.60	$48.80	$73.20
TOTAL PER TON HARVEST	$ 8.13	8.13	8.13	8.13
TOTAL GROW, HARVEST, AND STORAGE COSTS				
PER ACRE	$273.20	$321.10	$373.70	$460.80
PER TON HARVESTED	$ 91.06	71.35	62.28	51.20

1 Assume gross cash rent of land quality for 90 bushels of corn with market value of $1,000 per acre.

2 7% of total inputs, excluding land

SOURCE: R. A. Hinton , University of Illinois, November, 1988

Table 3. COST OF HARVESTING AND STORING HAY

Item	Harvesting Yield Per Cutting 1 Ton	1.5 Ton	2 Ton	2.5 Ton
Square Bales				
Machinery Costs				
Mower, Conditioner, swath......	$ 8.80	$ 9.00	$ 9.50	$10.00
Baler..........................	8.60	10.75	14.35	17.90
Tractor and wagon..............	5.40	6.30	7.20	8.10
Labor @ $6/hour				
Mow,conditioner, swath.........	2.65	2.75	2.85	2.95
Bale...........................	1.50	1.80	2.40	3.00
Haul and store.................	6.30	8.60	10.80	13.00
Management (7% of inputs)	2.35	2.75	3.30	3.85
TOTAL PER ACRE.................	$35.60	$41.95	$50.40	$58,80
PER TON	$35.60	$27.96	$25.20	$23.52
Large Round Bales				
Machinery Costs				
Mower,conditioner, swath	$ 8.80	$ 9.00	$ 9.50	$10.00
Baler..........................	6.00	8.00	10.80	13.60
Tractor and bale mover........	1.90	2.80	3.80	4.70
Labor @ $6/hour				
Mow,condition, rake............	2.65	2.75	2.85	2.95
Bale...........................	1.50	1.75	2.25	2.75
Haul and store.................	1.30	2.80	3.80	4.70
Management (7% of inputs).........	1.55	1.85	2.20	2.60
TOTAL PER ACRE.................	$23.70	$28.15	$34.00	$39.90
PER TON..................	$23.70	$18.76	$17.00	$15.96

SOURCE: R. A. Hinton University of Illinois, November, 1988

Replacement Strategies for Progress and Profit

Dewayne E. Dill

The replacement decision, ie. the decision to cull one cow and replace her with another, is one of the most important and most difficult decisions a dairy farmer must make. Many factors affect this decision including slaughter prices; availability of replacements; quality of replacements; production, health and reproductive status of the animal; herd goals; and production and cash flow needs.

Further complicating the decision is forced replacement of animals involuntarily culled due to acute illness, gross abnormal type traits, or death. Combining these factors with the uncertainty of any animal's future profitability, one can quickly conclude that no policy can be used that would apply to all situations. However, certain strategies can be used that will assure 1) progress toward specific herd goals and 2) present and future herd profitability.

HERD GOAL -- OPTIMUM GENETIC POTENTIAL

Replacement is a necessary tool for genetic progress. The genetic ability of any animal is unchanging over time. Thus, the only way to change the average genetic potential of the herd is to replace individual animals.

The goal of a replacement policy should be to assemble a herd of ideal individuals. The ideal individual is the animal that is most profitable. Thus, emphasis should be place on traits that are of economic importance and that have a genetic basis (Table 1). The most profitable animal will depend to some extent on your particular operation. However, this animal will have the following basic traits:

<ins>Production</ins> - Milk, fat, and protein yield are the most economically important traits. The ideal animal must maximize these traits without adversely affecting the other traits. As the industry becomes more responsive to consumer preferences, protein yield should be emphasized more than fat yield.

<ins>Reproductive efficiency</ins> - The ideal animal is one that can easily be rebred., She cycles regularly, displays visual signs of estrus and conceives when bred. While this trait is economically important, it has only a marginal genetic basis. Only the condition of cystic ovaries has been shown to be heritable.

<ins>Disease resistance</ins> - Disease resistance is a desirable trait for obvious reasons. Resistance to mastitis is of greatest economic importance. Wisconsin research has shown that susceptibility to mastitis, measured by high somatic cell counts, is heritable.

<ins>Type conformation</ins> - Dairy producers with registered animals often emphasize a number of traits related to type conformation. While all of these traits have a genetic component, only a few have been shown to be of economic importance. Strength of udder attachments, depth of udder and body size are related to milk yield; rump angle is related to reproductive efficiency; and correctness of feet and legs are related to longevity.

Disposition - The ideal animal must also have a gentle disposition. This is of particular importance in light of increased scrutiny by animal welfare / rights organizations. Animals that require extreme behavior to manage or that cause workers to behave in a cruel manner should be culled.

Your replacement policy should emphasize the traits you determine to be most economically important. For most operations, replacement should be based primarily on low milk production. However, replacement based on any trait you identified as a goal trait should not be considered as involuntary culling. You must make certain though, that the reason for culling is clear and that the animal chosen as a replacement is genetically superior for all traits than the animal culled.

STRATEGIES FOR PROFITABLE REPLACEMENT

Having determined the ideal animal for your operation, you are now ready to start working towards the ideal herd. The following strategies should accelerate genetic progress while maximizing profitability.

Managing Replacements

Most Illinois dairy farmers raise their own replacements. Managing these replacements properly is the key to rapid genetic improvement (see Table 2). Heifers should be managed to:

- Have at least 90% survive from birth to freshening
- Calve at 24 months
- Weigh 1250 pounds at 24 months
- Have calf sired by an A.I. sire

For genetic improvement, calves from 2-year-olds cannot be sacrificed. This will occur if heifers are bred to beef bulls or poor dairy bulls. In a 50-cow herd, breeding 2-year-olds to good bulls lets you cull five additional poor cows or undesirable heifers. Good heifers not needed in the herd are an excellent source of supplemental income.

Beef sires or "jumper" bulls are sometimes used for the convenience of getting heifers bred and to reduce calving problems. The following management practices are more profitable.

- Rely on good rations that grow heifers properly.
- Breed heifers at the right size and age.
- To reduce calving difficulties, select A.I. bulls with good calving ease ratings.
- Synchronize estrus for more convenient artificial insemination of heifers. Consult a veterinarian about this management practice.

Slaughter Prices

Maximizing the value of animals sold for slaughter is another strategy for profitable replacement. Two factors should be considered.

First, utility cow prices fluctuate throughout the year. In general, they tend to peak in March and September (see Figure 1). Most intensive culling should take place during these months. Second, cows sold for slaughter due to infertility and low production sell for a higher slaughter price than cows sold because of poor feet and legs and illness. This is due to the body condition of the animals. Depending on feed prices, it may be profitable, prior to sale, to add condition to cows intended for slaughter.

Dealing With The Profitable Problem Cow

What to do with a profitable cow that develops some problem is perhaps the most difficult of all replacement decisions. How long should you continue to rebreed the animal that won't "stick"? Should you treat a cow with mastitis, dry her up, or sell her? Should you operate on the cow with a displaced abomasum? How long should you continue to treat some other health disorder before it is no longer profitable? These are difficult questions that must be answered on an individual animal basis. The following principles apply:

- Dutch researchers found it was profitable to rebreed young animals in the top half of their respective production group for up to nine months post-partum. This number is undoubtedly longer than most dairy producers would tolerate; and current prices will alter this figure slightly. However, it is probably safe to conclude that it is profitable to try to rebreed animals longer than is typically practiced.

- High producing mastitic cows probably should not be sold immediately but should be milked last and monitored closely. If there is evidence that she is infecting other animals, she should be slaughtered immediately. Otherwise, if your milking management practices can contain her infection, she can continue to be milked until there is other justification for replacing her.

- Unhealthy animals tend to develop other problems. Research from New York found that cows with any type of health disorder during the first lactation were up to five times more likely to be culled during the following lactations than healthy animals. Canadian research has shown that there are relationships among clinical diseases (Table 3). For example, dystocia is often followed by an infection of the reproductive tract and teat injury is often followed by mastitis.

MEASURING SUCCESS

Good records are essential for optimal replacement decisions. The current productive, reproductive and health status of the animal as well as the reproductive efficiency and health disorders of the animal's ancestors should be known. Good records are also essential for measuring success.

The reason cows are culled is important. This information will identify whether you are replacing animals according to the herd goals you have identified.

The producing females to replacement ratio, percent first lactation animals, age of first calving and body weight at first calving are important indicators of proper replacement management. Optimum levels for these variables are in Table 4.

A final measure of success is the mature equivalent (ME) lactation average for first, second, third, and fourth and later animals (see Figure 2). The first lactation animals should have the greatest genetic potential. However, the low producing first lactation animals have not yet been culled. The most intensive culling should occur after the first lactation. Therefore, the ME lactation average should be highest for second lactation animals, followed by animals in their first, fourth and greater, and third lactation.

The replacement decision is difficult. There are many factors to consider. Each dairy producer must determine the policy that is best for his or her operation. The guidelines presented in this report should be useful for determining the best policy for your operation.

Table 1. Heritability of selected traits.

Trait	Approximate heritability
Yield:	
Mature Equivalent Milk	.20
Mature Equivalent Fat	.25
Protein	.25
Solids-not-fat	.25
Fat percent	.50
Protein percent	.50
Solids-not-fat percent	.50
Disease susceptibility:	
Mastitis	.10
Somatic cell score	.11
Milk fever	.05
Ketosis	.05
Breeding problems	.05
Cystic ovaries	.05
Milking characteristics:	
Milking speed	.30
Type conformation:	
Stature	.32
Strength	.22
Angularity	.16
Rump angle	.17
Rump width	.26
Rear legs side view	.15
Foot angle	.15
Fore udder attachment	.15
Rear udder height	.22
Udder support	.12
Udder depth	.26
Teat placement	.23
Final score	.28
Behavioral characteristics:	
Excitability	.25

Table 2. Surplus heifers in a 100-cow herd.

Heifers born[1]	Survival rate, %	No. heifers raised, birth to freshening	Replacement rate 15%	25%	35%
Calves saved from cows only					
45	90	40	25	15	5
45	80	36	21	11	1
45	75[2]	34	19	9	1
Including calves from freshening heifers[3]					
55	90	50	35	25	15
55	80	44	29	19	9
55	75[2]	41	26	16	6

[1] In a 100-cow herd, about 90 calves are born per year, half of which are heifers.

[2] Average survival rate from birth to freshening.

[3] With twenty 2-year-olds and 100 cows, total calf crop is 110 calves, half of which are heifers.

Table 3. Clinical diseases shown to be related.

Initial disease	Subsequent disease
Dystocia (veterinarian assistance)	Reproductive tract infection, < 21 days post-partum
Milk fever (cow down)	Digestive tract disorder
Milk fever (cow down)	Reproductive tract infection, > 60 days post-partum
Retained placenta	Abomasal displacement
Retained placenta	Reproductive tract infection, < 21 days post-partum
Abomasal displacement	Diseases of feet or legs
Mastitis (requires systemic therapy)	Mastitis (requires local therapy)
Teat injury	Mastitis (requires local therapy)
Mastitis (requires local therapy)	Diseases of feet or legs
Cystic ovaries	Reproductive tract infection, > 60 days post-partum
Diseases of feet or legs	Abortion

Table 4. Optimum levels for indicators of proper replacement management.

Indicator	Optimum level
Producing female : replacements	1 : 1
Percent first lactation animals	34%
Age of first calving	2-00
Body weight at first calving	
large breeds	1250
small breeds	950

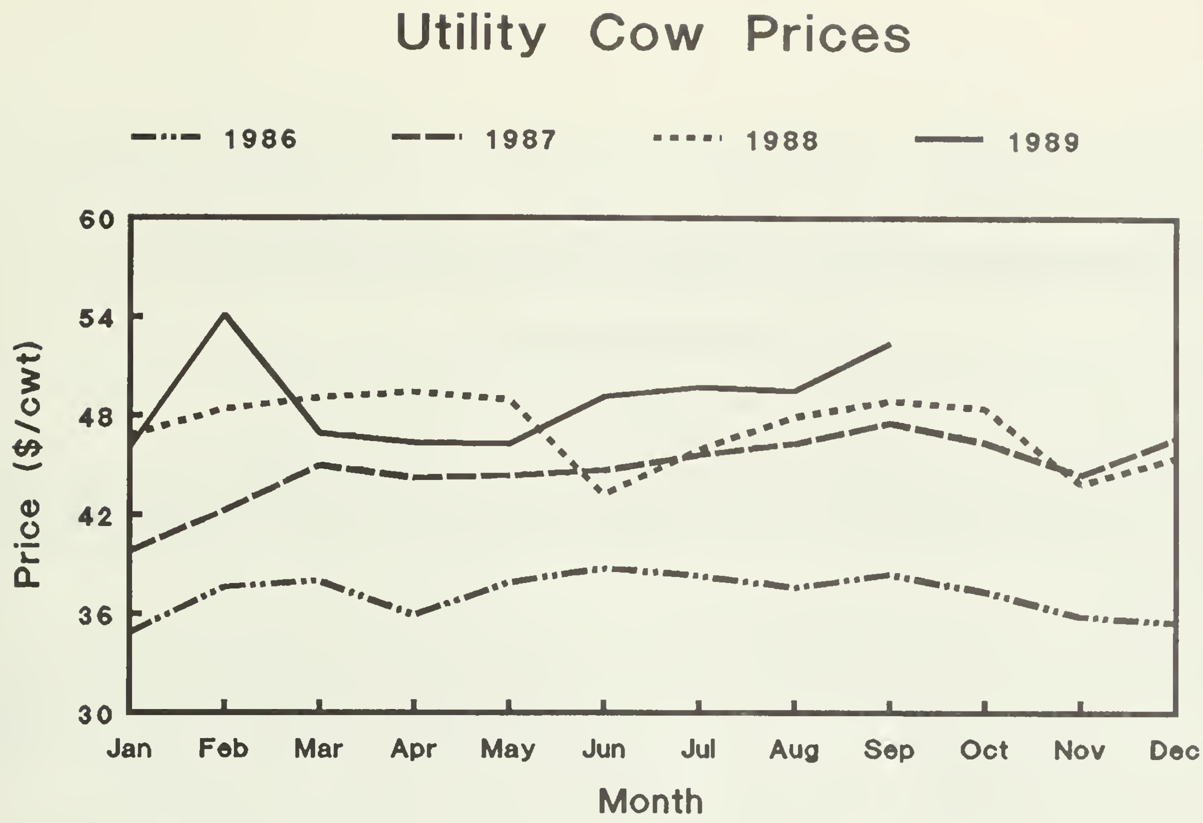


Figure 1. Utility cow prices by month.

IDENTIFICATION SUMMARY / HERD SIRE EVALUATION

AGE GROUP	NUMBER OF FEMALES	AVERAGE AGE	NUMBER IDENTIFIED: SIRE	NUMBER IDENTIFIED: DAM	WITHOUT PD	WITH PD	PREDICTED DIFFERENCES: MILK	FAT %	FAT	PROTEIN	$$
0–6 MONTHS	23	0-03	23	23		23	+925	-.06	+25	+23	+108
7–12 MONTHS	17	0-10	17	17		17	+885	-.04	+24	+22	+98
OVER 12 MONTHS	37	1-07	36	37	1	36	+710	-.03	+20	+21	+80
REPLACEMENTS	77	1-00	76	77	1	76	+814	-.04	+22	+24	+93
LACTATION 1	28	2-00	28	28		28	+705	-.02	+22	+23	+83
LACTATION 2	15	3-01	15	15		15	+534	-.01	+17	+18	+63
LACTATION 3	16	4-01	16	16	1	15	+342	+.05	+22	+20	+60
LACTATION 4 +	20	6-03	18	17	2	18	+117	+.02	+8	+10	+21
PRODUCING FEMALES	79	3-08	77	76	3	76	+390	+.01	+18	+19	+60
% IDENTIFIED →			98	98	13	75	+1226	-.05	+34	+33	+137 ← AVG. OF SERVICE SIRES WITH PD
					88	TOTAL	+1044	-.04	+29	+28	+117 ← AVG. OF ALL SERVICE SIRES

DRY DAYS SUMMARY

NUMBER < 40	NUMBER 40 – 70	NUMBER > 70	TOTAL: NUMBER	TOTAL: AVG DAYS DRY
8	36	7	51	52

LACTATION SUMMARY

	305-2X-ME: MILK	305-2X-ME: FAT	DIFFERENCE FROM HERDMATES: MILK	DIFFERENCE FROM HERDMATES: FAT
LACTATION 1	16.870	606	+547	+11
LACTATION 2	18.030	632	+1732	+36
LACTATION 3	17.610	629	+1342	+34
LACTATION 4 +	18.420	674	+2133	+71
PRODUCING FEMALES	17.620	632	+1323	+35

Figure 2. Example mature equivalent lactation averages for first, second, third, and fourth and later lactations.

Managing Chronic Herd Diarrhea Problems

R. David McQueen

GENERAL

The causes of diarrhea are so numerous that it is necessary to exclude those unlikely to cause chronic diarrhea in adult cows in a herd. First, internal parasites will be excluded because infections heavy enough to cause intermittent or severe diarrhea generally occur only in calves and replacement heifers.

Next, winter dysentery will be excluded because herd infection spreads rapidly and lasts only 2-4 weeks. The disease seldom re-occurs in less than 3 years, suggesting herd immunity resulting from an infectious agent. Recent research has tenatively identified a coronavirus as the causative agent. This virus has experimentally reproduced the disease in adult cattle. Its relationship to the coronavirus that causes neonatal calf scours is still not conclusively clear. Ultimately, a vaccine may be available to provide protection against winter dysentery.

Finally, salmonellosis will be excluded because Salmonella sp. most frequently cause severe diarrhea in calves less than 1 month of age. However, a small % of normal appearing cows in many herds are fecal culture (+) for Salmonella while residing on the farm, yet a high % of the culture (-) cows will be found to be shedding Salmonella in their feces after being transported a few miles to a slaughter facility or sale barn. This indicates the infection is often widespread in herds but not causing clinical disease, perhaps because competition by other intestinal bacteria keep Salmonella numbers very low. Occasionally, cows break with clinical salmonellosis (high fever and mild to severe diarrhea) immediately after calving. Salmonella also rarely causes mastitis in individual cows, similar to coliform type mastitis. The rest of the herd, however, usually does not show signs of Salmonella infection. The source of the udder infection is probably infected manure from the same or another cow. Bulk tank milk may also be contaminated with Salmonella via manure contamination of teats, if pre-milking udder preparation is poor. The presence of Salmonella in milk is a very serious potential human health problem. The possibility of human infection following consumption of unpasteurized or improperly pasteurized dairy products is great in individuals who are taking certain oral antibiotics for other health problems.

Three conditions commonly cause adult herd diarrhea problems lasting many months or years. They are Johne's disease, bovine virus diarrhea and rumen acidosis.

BOVINE VIRUS DIARRHEA

Most cattle owners are aware of the fact that bovine virus diarrhea (BVD) virus can cause embryonic death and abortion. But this virus may also be involved in a wide range of clinical disease syndromes such as acute and chronic diarrheas (mucosal disease) in susceptible (or partially immune) cattle of any age. Animals may also be simultaneously or sequentially infected with other diseases such as pneumonia because BVD virus infection suppresses the immune system.

When BVD was first identified in 1946 in New York, it caused herd epidemics of diarrhea, with ulcerations of the muzzle and mouth, reduction in milk production, cessation of rumen contractions, abortions, and occasionally death. A similar, but more prolonged disease with higher mortality, occurred in Iowa in 1953 and was named mucosal disease (MD). It is now known that the same virus causes both conditions.

Blood antibody surveys indicate from 60 to 80% of U.S. cattle and most herds have been exposed to BVD virus. In herds continuously exposed to BVD virus shed by persistently infected (PI) animals, the virus causes mild or inapparent infections (except for an occasional abortion) in immunocompetent animals. In the rare herd that consists entirely of totally susceptible animals, the introduction of BVD virus often causes an epidemic of acute diarrhea with occasional deaths, just as in the 1950's.

Fatal cases of mucosal disease also still occur. Some disturbing MD deaths have occurred following vaccination with modified live BVD vaccine, but MD has also followed vaccination with rota-corona vaccine, and more recently bovine respiratory syncytial virus vaccine. After years of research, the mystery of MD and BVD transmission is nearing solution. Key findings include:

1. Cattle are the principal reservoir of BVD virus, although sheep, goats, swine and wild ruminants (including deer and antelope) may be infected. Cattle that are persistently infected (PI) are exposed as fetuses to a non-cytopathic strain of the virus prior to the 120th day of pregnancy. Normal appearing PI calves that survive to adulthood shed the virus in all body secretions in higher concentration than cattle acutely ill with BVD. Refer to the accompanying chart.

2. Mucosal disease occurs when a PI animal (infected with non-cytopathic strain virus) is exposed to a closely related cytopathic strain virus (either a field virus or a modified live vaccine virus). There is speculation about the source of the field cytopathic strain virus. Circumstantial evidence in some herds suggests mutation from a non-cytopathic virus in the herd.

3. From 0.4% to 1.7% of all cattle are PI. Thus, it is highly probable that pooled fetal calf serum collected randomly from pregnant cows at slaughter will contain non-cytopathic BVD virus. This has serious implications for spread of BVD virus through procedures that utilize bovine fetal calf serum; i.e., the tissue culture media used in vaccine production, and embryo collection and transfer procedures.

4. BVD vaccines are subjected to USDA efficacy tests requiring vaccination of animals (feedlot steers are usually used), which are then challenged with the live, field virus strain(s) used in the production of the vaccine. Protection against dissimilar strain(s) of BVD virus <u>is not evaluated</u>. Vaccine trials also do not test for the ability of vaccines to protect against fetal infection and abortion. Killed BVD vaccines, in general, produce lower levels of serum antibody than modified live virus (MLV) vaccines and often do not provide adequate protection against BVD abortion. MLV-BVD vaccines should not be used in pregnant animals as the modified virus multiplies and may cross the placenta to infect the fetus. PI animals and/or abortion may result. Thus, MLV vaccine use should be restricted to heifers 6-12 mos. of age which do not have contact with pregnant animals. MLV vaccine may, however, cause fatal mucosal disease in PI animals if they are infected with a closely related strain of virus. This may actually be an advantage in a purebred herd - i.e.; the possibility of PI animals being retained as herd replacements is prevented.

Inclusion of non-cytopathic and cytopathic strains of BVD virus in the same vaccine does not necessarily provide cross-protection against all BVD strains i.e., both vaccine strains may be closely related and thus two strains may be no better than one.

5. Testing all animals in a closed herd and removal of PI animals should render the herd free of BVD virus. This would be the ideal way to eliminate BVD abortions and the production of PI animals. A DNA-BVD probe to detect PI animals is now being field tested. Virus isolation has also been used to identify PI animals, but is laborious and more expensive - its use has generally been limited to AI bull studs.

In summary, BVD abortions may occur in BVD vaccinated herds, if an unrelated BVD strain is introduced or if vaccinated partially immune animals are exposed to PI animals. Serum samples collected prior to breeding and after abortion are required to provide definitive information about BVD status in vaccinated herds which experience abortions.

JOHNE'S DISEASE

Mycobacterium paratuberculosis infection causes intermittent and eventually continuous diarrhea with severe weight loss. Milk production and reproductive efficiency are reduced, and disease problems are increased. Johne's disease appears to be increasing in dairy herds due to increasing confinement and therefore greater likelihood of exposure and spread. For a more detailed discussion, refer to previous Area Dairy Days handouts.

Progress in the development of DNA/RNA probes to identify Johne's fecal (+) cows is encouraging. An RNA probe developed at the U-I is now being field testsd. But Elisa serum tests to identify exposed animals require further refinement to reduce the frequency of misleading false (+) tests (cross-reaction with other mycobacteria of the MAIS complex).

Ohio researchers have reported results of a limited study showing that approximately 25% of Johne's fecal (+) cows give birth to infected offspring. Thus, when culling a fecal (+) cow or a Johne's suspect, offspring of that cow should also be culled, or if retained, subjected to repeated fecal culture testing. In herds using Johne's vaccine, offspring of fecal (+) cows should not be vaccinated, because such vaccinates may ultimately become fecal shedders.

RUMEN ACIDOSIS

There are three rations fed to dairy cows: the one calculated, the one actually fed, and the one individual animals eat. Rumen acidosis (lactic acidosis) results from a sudden increase in the consumption of grain, such as a dry cow routinely fed roughage and suddenly fed grain, or an animal fed grain in small amounts which suddenly consumes an increased amount of grain at one feeding. An animal that goes off feed for 2-3 days and then abruptly resumes grain eating may also experience rumen acidosis. Rumen acidosis is clinically defined as a decline in rumen pH below 5.5 (an increase in acidity). Symptoms vary, depending on how low the rumen pH drops and for how long the low pH exists. Usually an increased consumption of 5 or more pounds of grain at one feeding has a significant effect on rumen fermentation and rumen pH.

However, there are many variables that determine the magnitude of rumen pH changes in an individual animal. Where animals are group fed there may be great individual variation in grain and forage intake such that aggressive animals may consume 2-3 times as much grain as less

aggressive/smaller animals. Forage factors that also modify rumen pH changes include meal size, length of cut, feeding frequency and sequence, and type (legume, grass, corn silage, haylage).

The variety of grain, average particle size (ground vs. rolled) meal size, amount and rumen degradability of protein present with the grain, and amount and type of added buffers also influence rumen flora, fermentation and pH. Sudden weather changes can also markedly increase or decrease dry matter intake, and especially the type of feed consumed, if certain feeds are feed indoors and others are fed outside in unprotected bunks.

Until recently, grain feeding was known only to cause shifts in the type and numbers of rumen flora i.e., an increase in total number of micro-organisms and an increase in the % of starch digesters and a decrease in % of fiber digesters. It is now recognized that the rumen lining undergoes gradual proliferation or reduction (papillae surface area increases or decreases), depending on the amount of propionic and butyric acid produced in the rumen. The fermentation of grain or grain by-products (starch and other non-fibrous carbohydrates) results in increased production of propionic acid and a lower proportion of acetic acid. Thus, in the dry cow fed limited or no grain, the papillae shrink. As grain feeding resumes and increases just before and after calving, the papillae begin to increase in size. Maximum size is reached at peak grain intake during lactation.

European research indicates that cows that have long dry periods (and thus fed less grain or no grain) reach peak dry matter intake and peak papillae size later than cows with shorter dry periods. This is because papillae shrink more in cows with long dry periods and therefore take longer to reach maximum size after calving. Such cows are more prone to acidosis in early lactation because of reduced surface area for absorption of fermentation acids. Refer to the accompanying diagram.

Greater amounts of propionic acid is produced and absorbed in grain fed animals, a function of papillae size. Also, more rapid absorption of rumen acids occurs as rumen pH declines from 6.5 to 6.0. Significant shifts in rumen flora occur from predominately fiber digesters at pH 6.5 to predominately starch digesters at pH 5.5 to 6.0.

However, with a marked increase in grain consumption, fermentation patterns change even further as rumen pH falls to 5.5 or below. Gram (+) streptococcus and lactobacillus bacteria now predominate. Lactic acid produced by these bacteria is the principal fermentation end-product. Rumen osmotic pressure increases because lactic acid is poorly absorbed. The accompanying diagram of acute/subacute rumen acidosis depicts the chain of events that ensues, affecting the entire digestive tract.

The entire disease process is complex and variable, depending on the factors previously discussed. Even "rumen adapted" cows on full feed may overeat and develop acute, subacute or chronic acidosis under certain circumstances. Acute acidosis occurs less frequently in dairy herds than in feedlot cattle, because of the larger amount of forage in dairy rations. However, repeated bouts of subacute or chronic acidosis are much in evidence as reflected by the high incidence of foot problems (laminitis, sole abscesses, etc) in some dairy herds, and the frequent observation of liver abscesses at slaughter. Recent U.S. and English studies indicate lameness causes a greater increase in calving to conception interval than retained placenta, metritis or ovarian cysts.

Less frequently recognized possible consequences of mild or chronic acidosis are the loose stools/diarrhea episodes in individual cows that are often attributed to infectious diseases such as

Johne's disease or BVD. Weight loss and decreased appetite usually accompany chronic acidosis. Repeated (cyclic) bouts of acidosis may lead to chronic rumenitis/liver abscess formation. Weight loss may also be caused by Johne's, BVD, prolonged negative energy balance (without clinical ketosis) and ration formulation problems.

Experiences in one well managed Illinois herd concurrently affected with BVD, Johne's disease and chronic acidosis will be presented. Such a herd presents a great diagnostic challenge to determine the principal cause of diarrhea and weight loss. The discussion will include lost production and replacement costs, the corrective measures taken, and the continuing improvement in production after management changes were implemented.

In conclusion, it is apparent that chronic/intermittent diarrheas are an increasing problem in dairy herds, especially those in which early lactating cows are no longer fed individually. Feeding changes occuring during the transition from the dry cow diet to the lactation diet are often the forerunner of chronic acidosis and abomasal problems in lactating cows.

BVD infection (non-cytopathic strain)

Immune pregnant cow

Normal, healthy virus-free calf which can respond normally to a naturally acquired BVD infection or to a BVD vaccine.

or

Infection of fetus with a BVD virus unrelated serotypically to the one to which the cow is immune results in the same consequences discussed for nonimmune cow.

Nonimmune pregnant cow

Days of gestation

up to 100-120

Embyronic death, abortion, stillbirth, mummification

or

Carriers with persistent viral infection, weak or clinically normal at birth, normal or unthrifty in postnatal life. A proportion develop fatal mucosal disease at 6 to 24 months. Others live much longer and can give birth to persistently infected cattle.

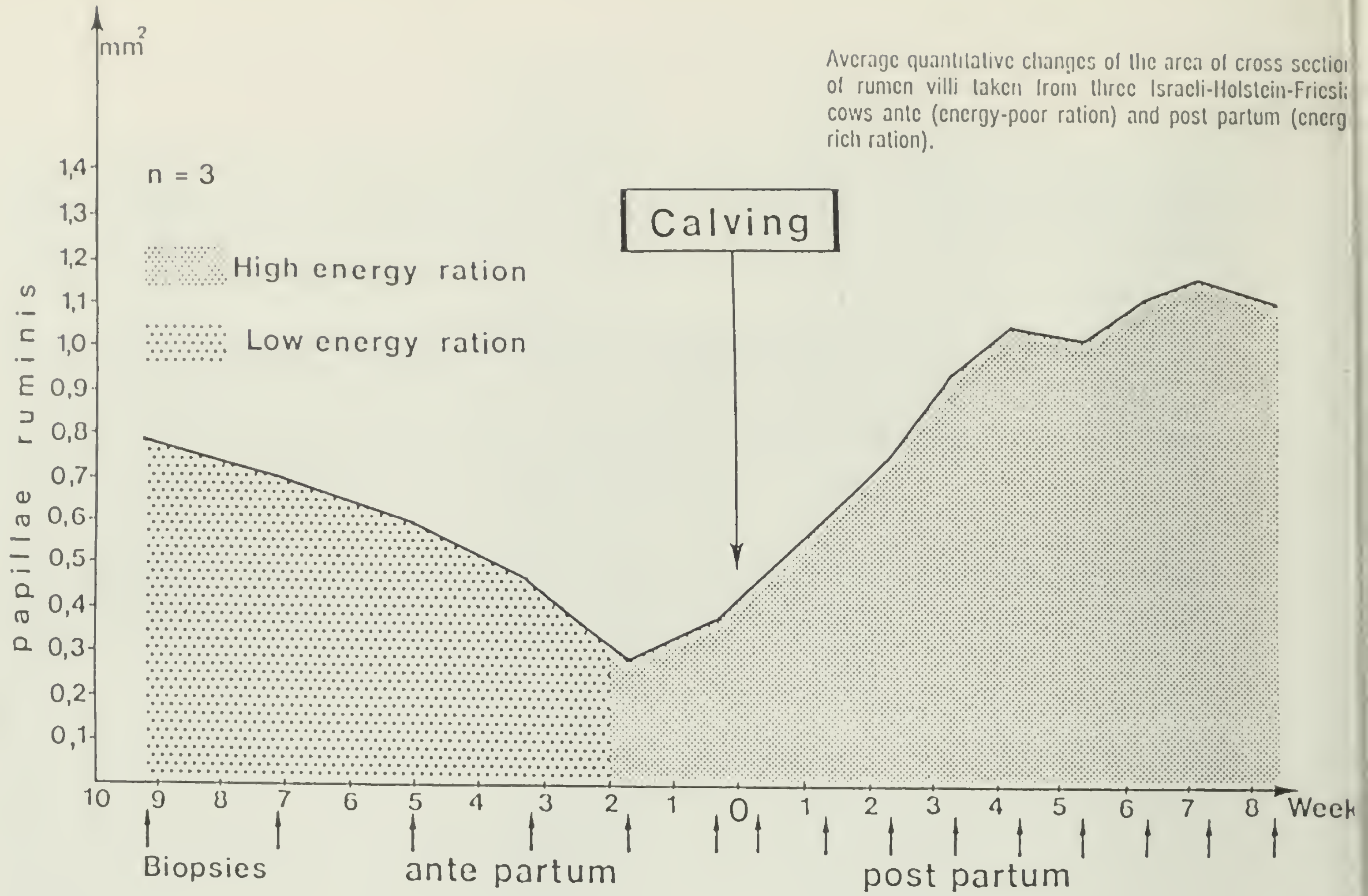
120 to 150

Congenital abnormalities of nervous system and eyes.

after 180

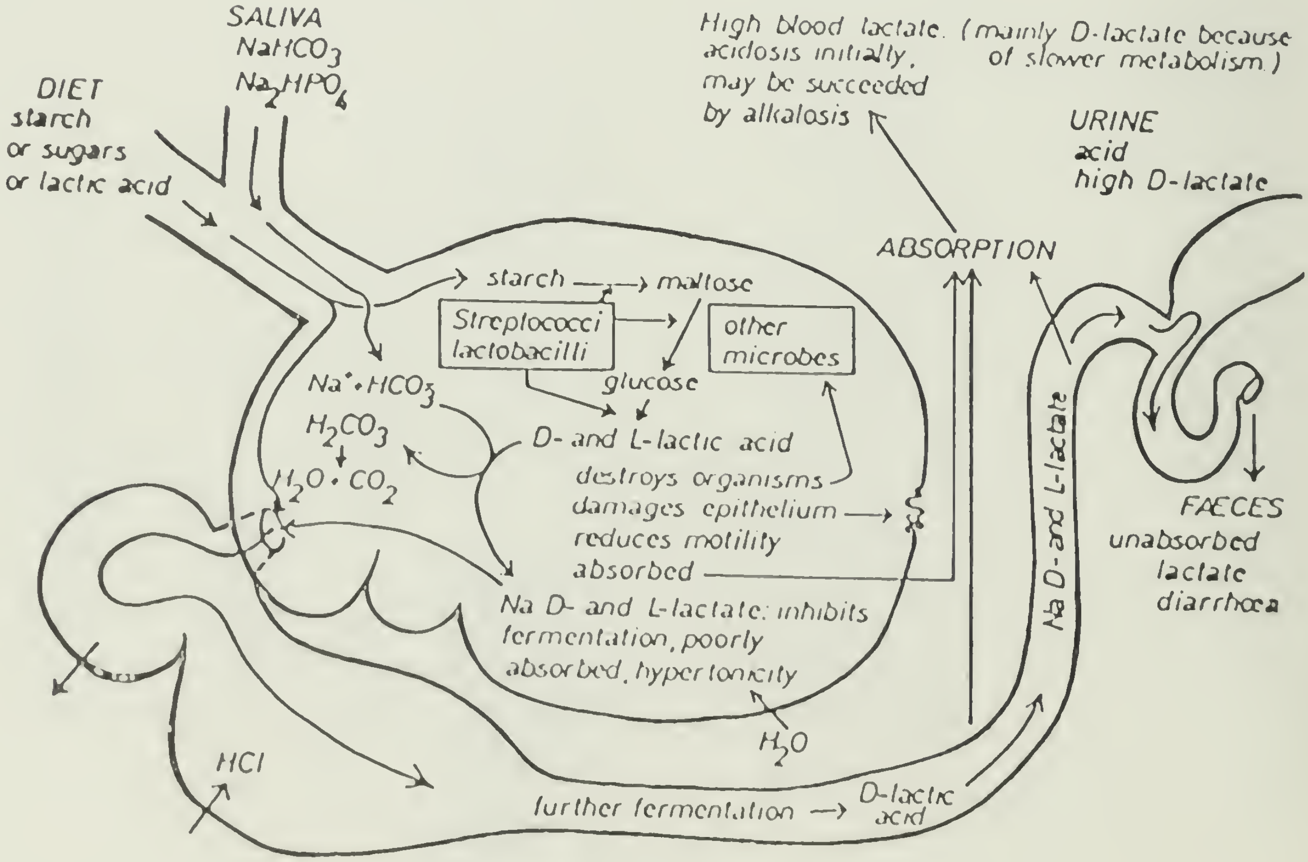
Usually no effect except production of antibody to BVD virus.

Ron Schultz
U of Wisconsin
1989 (Modified)



Average quantitative changes of the area of cross sectio of rumen villi taken from three Israeli-Holstein-Friesi cows ante (energy-poor ration) and post partum (energ rich ration).

Dirksen et. al.
The Bovine Pract.
#20, Nov. 1985



Wass et. al.
Current Veterinary Therapy 2
Food Animal Practice p. 717

Update on Spirochetal Infections

R. David McQueen

LEPTOSPIRA BRATISLAVA

Leptospirosis due to L. pomona was first diagnosed in Illinois in the early 1950's. It caused "red water", an acute illness, with jaundice and bloody urine in 50% of cases and sometimes death in replacement heifers and steers. In cows the disease begins as a mild illness characterized by a decline in milk production and the secretion of colostrum-like fluid in all quarters, without visible inflammation or swelling of the udder. The physical changes in udder secretion are very suggestive of Leptospirosis. Infected pregnant cows occasionally abort with the placenta retained. Infected cows shed large numbers of the organism in urine for 2-4 months. Such urine may infect feed or water or splatter onto the skin or eyes of other cattle or people and transmit the disease.

L. hardjo was recognized as a cause of reproductive failure in cattle in Illinois in the late 1950's. Cattle are the maintaining host for this strain of lepto. Extensive vaccination has markedly reduced infections and abortions due to L. pomona, but early embryonic death caused by L. hardjo has been less well controlled. This is because the available bacterins do not provide long lasting immunity and vaccination is often given too late. That is, after the animals are already infected and vaccination does not clear the infection. Colostral antibody from immune dams is lost by 4-5 months of age. Exposure to natural infection after that time, but prior to vaccination, may result in persistent kidney/uterine/oviduct infections. The bacteria are shed in the urine for 1-2 years, usually infecting all herd members at some time in their lives. Infected animals may exhibit repeated conception failure/early embryonic death, but test negative on the microscopic agglutination test. To diagnose L. hardjo infection test at least 10 animals representing the yearlings, 1st lactation and 2+ lactation groups.

Research in New Zealand indicates heifers should be vaccinated twice at 4-6 week intervals starting at 6 months of age to obtain optimum protection against L. hardjo. Revaccination at 6-12 month intervals is also required for continued protection.

Recently, another strain of leptospira, L. bratislava, has been identified as the most common Leptospira in midwestern swine. This is not a new strain as serum samples collected in the early 1970's from workers at an Illinois hog slaughter plant have now been tested and found to react to L. bratislava antigen. In Europe, the European hedgehog was demonstrated to be a maintaining host for this leptospira in the early 1950's. European experiments established that L. bratislava caused kidney disease with bloody urine and often death, especially in younger calves.

Survey results of a small number of Iowa beef cattle herds in 1989 revealed the presence of antibody in 25% of herds studied with 11% of the cows testing positive. At this time, the significance of a positive serum test for L. bratislava in U.S. cattle is unknown. The distinct kidney damage and bloody urine produced experimentally in young calves suggests clinical symptoms may differ somewhat from infections caused by L. hardjo. Serum samples collected prior to infection, during infection, and after infection or abortion will help to establish what clinical symptoms are

associated with L. bratislava infection in midwestern dairy cattle. Refer to the article entitled "Serum bank" in these handouts.

LYME DISEASE

Lyme disease (LD) or Borreliosis (as Lyme disease in animals other than humans is often called) is a bacterial infection of humans, dogs, cats, cows, horses, and wildlife. It is caused by the spirochete, Borrelia burgdorferi. Since the 1975 report of a human LD outbreak in Old Lyme, Connecticut, this disease has rapidly surpassed Rocky Mountain spotted fever as the most frequently reported tick-transmitted human illness in this country. The amount of publicity about LD has been tremendous recently.

Lyme disease has now been reported from at least 43 states including Illinois and every continent except Antarctica. In Illinois, the reported incidence of LD is increasing. In 1987 six cases of Lyme disease in humans were reported to the Department of Public Health, only two of which were contracted in Illinois. In 1988 (the first year the Dept. of Public Health made Lyme a reportable illness) the number of LD cases doubled. Fifty percent of these cases apparently originated from tick bites received in Illinois. From January to September, 1989 there were 55 Illinois residents in 30 counties (see map) with confirmed Lyme disease contracted in state and another 120 cases in which out-of-state travel may have been the source of exposure. Public Health Dept. officials believe the disease is now endemic (two or more cases per county yearly) in the following Illinois counties: Carroll, Grundy, Jo Daviess, Lake, LaSalle, Lee, Macon, Mercer, Rock Island, and Winnebago.

In addition, University of Illinois College of Veterinary Medicine researchers Drs. Uriel Kitron and Carl E. Kirkpatrick have documented the presence of the deer tick, Ixodes dammini, which is probably the primary vector of human LD in Illinois. They have found the deer ticks on deer from eight Illinois counties: Carroll, Jo Daviess, Kankakee, Lee, Mercer, Ogle, Piatt, and Rock Island. Field surveys in the summer of 1989 indicate that the density of the ticks is on the rise and that some 20% of the ticks are infected with Borrelia burgdorferi, the spirochete that causes LD.

Borreliosis in cattle, horses, dogs, cats and wildlife may be acquired from the bite of deer ticks, but the spirochete has also been isolated from dog ticks, bot flies, mosquitoes and one type of flea. Transmission has also been shown to occur in dogs and in the white footed (deer) mouse by direct contact with infected animals. The spirochete has been isolated from urine of deer mice, dogs and cows. It is speculated that contact with infected urine may result in transmission of the disease. This has implications for possible human exposure, especially at milking time when urine splatter may occur. Leptospirosis, also a spirochetal infection, has spread form cows to humans in this manner. Experimental studies with Leptospira hardjo in 8 month old replacement heifers showed that inoculation onto the eye results in high infection rates, although intravenous injection did not.

The signs of Borreliosis in animals, as LD in humans, can be quite variable. The rash-like ring frequently seen at the site of the tick bite in humans either does not occur or is seldom seen in cattle. Clinical signs in cows include redness, warmth, swelling, and skin hypersensitivity of the ventral udder and lower rear legs. Swelling of the pastern and fetlocks, lameness, and interference with milk letdown also have been reported from clinical cases. The spirochete has been cultured from the blood of a cow that aborted and that of a newborn calf. An aborted calf also had antibodies to B. burgdorferi, suggesting uterine infection. Experimental proof of abortion due to

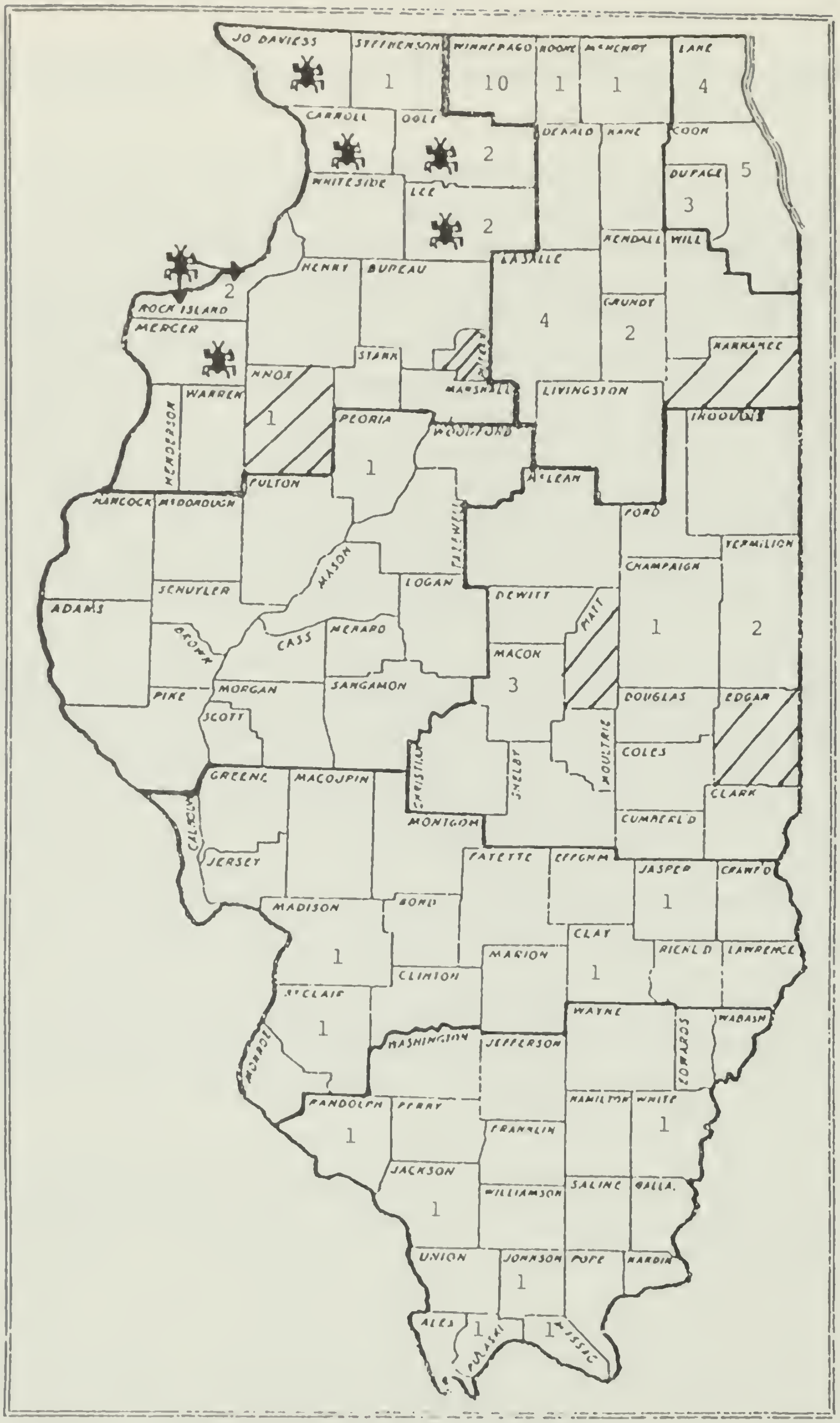
Borreliosis is lacking, but a related tick transmitted Borrelia specie has also been linked with foothill abortion in California beef herds.

Diagnosis of Lyme disease in animals is based on history, clinical signs, serology (serum analysis), tissue analysis, and response to therapy. Serology is the most commonly used laboratory test to aid in diagnosis. An indirect immunofluorescent antibody test (IFA) or an enzyme linked immunosorbent assay (ELISA) of serum is used to determine antibody level to Borrelia burgdorferi in animals. Antibodies may persist for months following infection so a single (+) test suggests exposure, but does not prove recent infection. In endemic areas, the number of IFA seropositive dairy cattle greatly exceeds the number of confirmed cases showing clinical signs. This test appears to lack specificity in cattle; i.e., the test antigen may cross-react with other Borrelia strains or other spirochetes (false +). Limited evidence in dogs suggests vaccination induced Leptospiral antibodies may cause low titer (false +) test results. Also, it is not known if animals which are truly seropositive and asymptomatic will eventually exhibit clinical disease. Thus, treatment of animals based only on seropositivity remains controversial. In addition, there appears to be no clear correlation between antibody levels and severity of clinical disease.

Response to treatment in the acute cases of Borreliosis can be rapid and dramatic. An almost complete relief of pain and lameness may be seen within 24 hours (dogs) or 48 hours (cows) after the onset of antibiotic therapy. However, chronic cases respond much more slowly, and it may take months before a response is seen. Thus, treatment for at least 14 days is advised. The cultural isolation of the spirochete in clinical cases and/or high joint fluid antibody titers remain the most convincing evidence on which to base treatment decisions. The prolonged milk discard required for lactating cows makes treatment very expensive. In one proven infected dairy herd near Lyme, CT only 1-2 clinical cases are diagnosed yearly, suggesting a careful evaluation to rule out other causes of joint swelling and lameness should precede treatment for Borreliosis.

The knowledge of Lyme disease/Borreliosis is increasing as more cases are diagnosed. Accumulated evidence suggests that this is not a new spirochetal disease. The increased number of diagnosed cases in humans reflects an increasing awareness of the disease as well as an apparent increase in the infection rate and spread of the disease.

A vaccine for cattle may eventually be developed, but like Leptospira bacterins, is not expected to provide long term immunity. Attempts to control the disease by controlling deer or white-footed mice or Ixodes ticks are impractical.



Key

- Counties where Ixodes dammini has been found in the environment, i.e., vegetation or ground.

- Counties where single deer ticks were found on a dog or deer but not in the environment.

University of Illinois
Research Reports

Fatty Liver in Dairy Cows

James K. Drackley

Fatty liver (i.e., "fatty liver syndrome" or "hepatic lipidosis") is an ill-defined metabolic disorder that affects dairy cows around the time of parturition. The disorder is characterized by fatty infiltration of the liver, increased incidences of other common postparturient diseases and disorders, and poor responsiveness to treatment for other diseases. This brief review will discuss the occurrence, physiology, diagnosis, treatment, and prevention of fatty liver in dairy cows.

OCCURRENCE AND CONSEQUENCES

Rather than considering fatty liver to be a separate disease, it is helpful to think of it as a symptom of a generalized failure of the cow to adapt her metabolism to the demands of early lactation. Fatty liver may develop in at least four situations:

1. "Spontaneous" in early lactation. British researchers found that nearly all "normal" cows had detectable fat in their livers at 1 week postpartum; the incidence was much less by 8 weeks postpartum. Up to two-thirds of all Holsteins in those studies had moderate to severe fatty infiltration of the liver. Estimates of incidence in the USA generally have been lower, in the range of 20 to 30 percent of all cows.

2. In fat cows after calving. Fat cows (body condition score of 4.5 or greater on a 5-point scale) are susceptible to development of fatty liver as part of the "fat-cow syndrome". Incidences of sickness and death in these cows are very high.

3. During food deprivation or starvation. Starvation of cows at any stage of lactation leads to accumulation of fat in the liver, with cows in early lactation being most susceptible. Michigan State University researchers, however, even observed fatty livers in dry cows maintained on an inadequate plane of nutrition.

4. Secondary to other diseases or disorders. Fatty liver often develops subsequent to other infectious and metabolic diseases, especially in cows during early lactation. Researchers at Michigan State University showed that fatty livers in cows undergoing surgery to correct displaced abomasum could not be attributed to decreased feed intake alone, because the degree of fatty liver was much greater than in cows that were starved for 7 days at the same stage of lactation. This suggests that factors triggered by trauma or disease may contribute to development of fatty liver.

One of the most widely publicized effects attributed to fatty liver is decreased reproductive performance. British studies showed increased intervals to first estrus and increased services per conception in cows with fatty liver. No direct physiological connection has been established, however, between poor reproductive

performance and fatty liver. Other studies have linked fatty liver to increased incidence of infectious and metabolic diseases. In a British study, cows with fatty liver retained viable pathogenic bacteria in the mammary gland for a longer period after experimental infection than did control cows; fatty liver also was associated with decreased numbers of circulating white blood cells, particularly the neutrophils, eosinophils, and lymphocytes. It has been hypothesized that fatty liver may increase incidence of milk fever by altering liver metabolism of vitamin D, but this hypothesis has not been tested experimentally.

PHYSIOLOGY

The fat that accumulates during development of fatty liver is mainly triglyceride, formed when long-chain fatty acids are esterified to glycerol. Because fatty acids are not synthesized in the liver of ruminants, the fatty acids must come from those mobilized from adipose tissue and taken up subsequently by the liver. Figure 1 shows the relationships between mobilization of fatty acids from adipose tissue and development of fatty liver. Low concentrations of glucose and insulin in blood during early lactation promote lipolysis in adipose tissue, with the resulting free fatty acids (FFA) released into the blood. Increasing evidence suggests that some FFA may be incorporated directly into milk fat by the mammary gland when concentrations of FFA in blood are elevated during early lactation. The liver and other organs take up FFA in proportion to their concentration in blood, so that more FFA are taken up by liver when circulating concentrations of FFA are high.

Once taken up by the liver, FFA can be 1) oxidized to carbon dioxide to provide energy to the liver, 2) partially oxidized to produce ketone bodies or acetate that are released into the blood and serve as fuels or substrates for other tissues, including the mammary gland, or 3) esterified to form triglyceride. Factors that cause increased liver synthesis of triglyceride from FFA in ruminants are understood poorly. Triglyceride is exported from the liver of non-ruminant animals in the form of very low density lipoprotein (VLDL) particles, but Wisconsin workers demonstrated that ruminant liver can export only limited amounts of VLDL. Consequently, increased synthesis of triglyceride leads to accumulation of triglyceride and development of fatty liver.

SYMPTOMS AND DIAGNOSIS

Severe or clinical fatty liver most often occurs shortly after calving, in contrast to diseases such as ketosis that usually occur from 4 to 8 weeks after parturition. Producers report that cows affected with fatty liver "have not been normal since calving" and are "poor doers". A concurrent disease such as milk fever, persistent ketosis, displaced abomasum, metritis, mastitis, or retained fetal membranes is often present. The distinctive feature of clinical fatty liver is a poor response to usual therapies for the concurrent disease. This results in prolonged recovery times, high incidences of repeat treatments, and increased culling or death losses from seemingly minor diseases.

Many diagnostic tests have been proposed to detect fatty liver, including activities of various enzymes in blood serum, clearance of injected dyes or propionate from blood, and concentrations of various metabolites in blood or urine. These tests generally have proven not to be sufficiently sensitive or specific for detection of fatty liver. Concentration of FFA in blood is related

most closely to development of fatty liver, but many clinical chemistry labs do not perform this analysis routinely. The only accurate method of diagnosing fatty liver remains determination of fat content in a piece of liver obtained by biopsy. Liver biopsy is a relatively simple procedure that can be performed by most veterinarians. Diagnosis of fatty liver by any means may only provide confirmation of the existing condition; fatty liver can develop so quickly that it may be too late for successful treatment by the time a biopsy or blood samples can be obtained and analyzed. Researchers have demonstrated that fatty livers can develop in as little as 48 hours during early lactation.

The degree of fatty liver can be classified in various ways, depending on whether fat is determined microscopically as a volume of liver occupied by fat or whether fat is determined chemically, either as total lipid or triglyceride. Table 1 shows one scheme for classifying fatty liver, with roughly equivalent fat contents shown as determined by different methods.

The outlook for cows with severe fatty liver worsens as fat content increases. Cows with greater than 35 percent total lipid (or 70 percent microscopic fat) have little functional liver tissue left; these cows will be clinically ill and have a very poor prognosis for recovery. Cows with moderate fatty liver may not display clinical symptoms but are at increased risk for development of other problems.

TREATMENT

Treatment of fatty liver is aimed at decreasing mobilization of FFA from adipose tissue and thereby preventing further fatty infiltration of the liver. Intravenous glucose, glucose precursors such as propylene glycol, slow-release insulin preparations, and pharmacological doses of niacin all have been reported to be helpful. Cows that are not eating should be fed by stomach tube several times each day a "gruel" made by adding water to a commercial complete feed. Of great importance is that any concurrent diseases be treated aggressively. As discussed already, success of treating fatty liver is determined largely by the degree of fat present.

PREVENTION

Preventing fatty liver usually is more successful than treatment. Management during the dry period is extremely important, as the cow prepares for her next lactation. Body condition should be adjusted during late lactation to a score of 3.5 to 4.0 and then maintained through the dry period until calving. Fat cows should be avoided. Feeding 6 grams per head per day of niacin may be beneficial in problem herds. Introduce grain into the diet during the last two weeks before calving, but do not exceed 10 pounds per head per day before calving.

At time of calving, the two most important factors are to 1) maximize intake of high-quality feeds, and 2) keep extra stresses to a minimum. If possible, group fresh cows (<30 days after calving) so that they can be managed separately. Feed an abundance of the highest-quality forages available, and increase intake of grain slowly during the postparturient period. Excessive loss of body tissue during early lactation should be avoided. Cows should not lose more than 1 unit of body condition score during the first 30 days postpartum. Niacin at 6 to 12 grams per head per day may be helpful. Handle fresh cows carefully and quietly.

Provide adequate bunk space and waterers so that "social" stresses of competing with large numbers of aggressive herdmates for feed and water are avoided. Any additional stress during the early postpartum period can lead to rapid and dramatic increases in release of FFA from adipose tissue, and therefore increase risk of development of fatty liver.

Added dietary fat may be beneficial during the early postpartum period, because dietary fat absorbed in the intestine should supply extra energy for milk synthesis, but bypass the liver. Research is lacking, however, concerning effects of dietary fats on liver function during the early postpartum period. Dietary fats may lead to increases in FFA in blood, which if excessive could cause deposition of fat in the liver. A safe recommendation may be to feed fat from a natural source, such as whole soybeans or tallow, at the rate of about 1 pound of added fat per head per day after calving, and then to increase the amount of fat after 30 days postpartum, if desired, by adding more tallow or a rumen-protected fat source.

Although it is important to provide adequate supplies and proper balance of rumen degradable and undegradable protein, excesses of either type of protein should be avoided. Nitrogen from excess degradable protein must be detoxified by conversion to urea in the liver, which imposes additional metabolic demands on the cow for energy. Excess rumen degradable protein also has been linked to reproductive problems. Overfeeding rumen undegradable protein should be avoided as well, both because it is expensive and because some research suggests that it may stimulate greater mobilization of FFA from adipose tissue.

So-called "lipotropic" substances, such as choline, inositol, and cyanocobalamin, generally are only marginally effective in promoting export of fat from the liver of dairy cows. There is circumstantial evidence that protected methionine sources may improve utilization of fats and help prevent fatty liver, but experimental data are lacking and the effects are likely to be small.

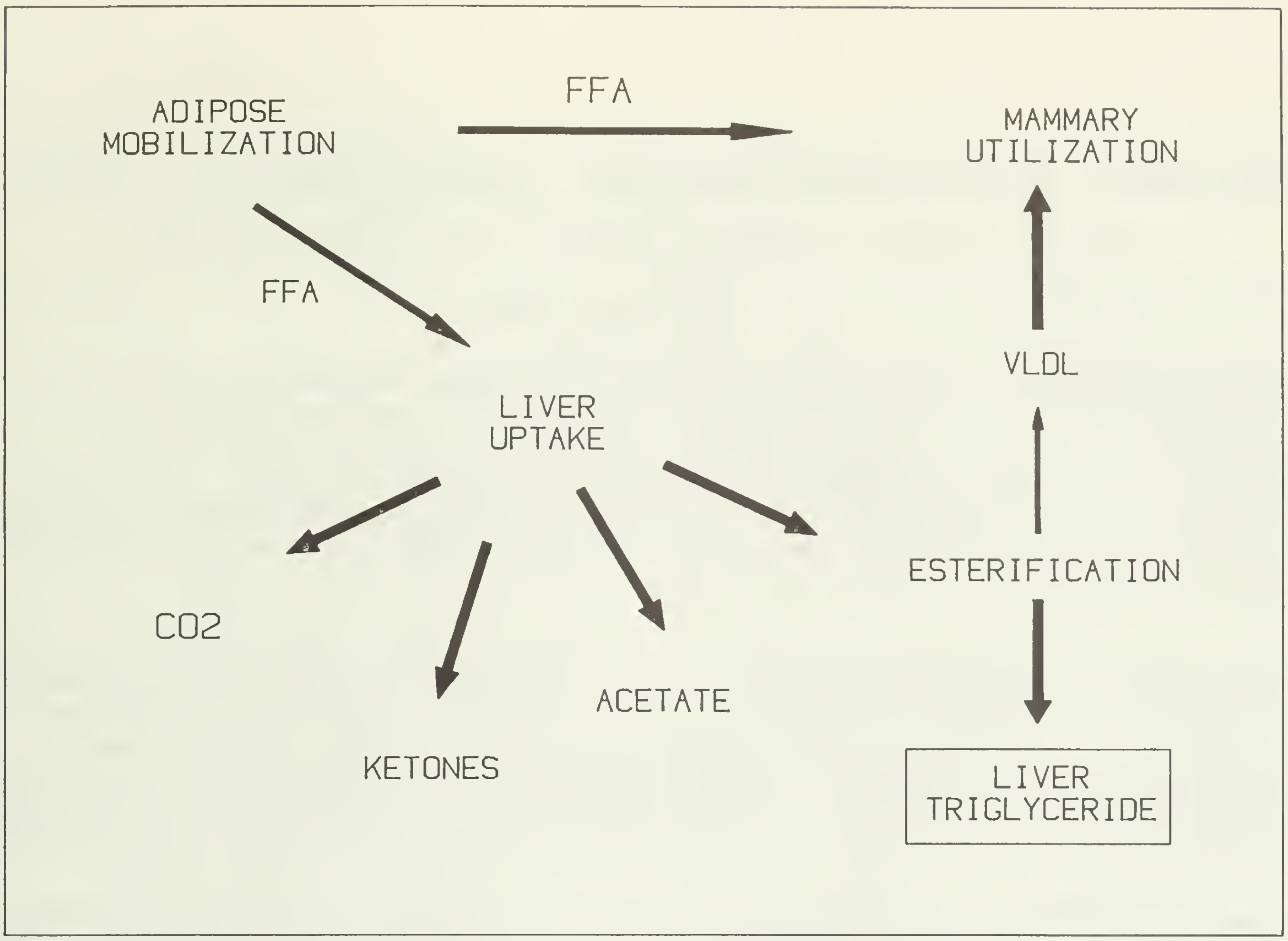


Figure 1. General flow of free fatty acids (FFA) leading to formation of liver triglyceride during development of fatty liver in dairy cows.

Table 1. Classification of fatty liver, with fat content measured by different methods.

Severity	Microscopic fat, %	Total lipid, %	Triglyceride, %
Mild	0-20	<10	<5
Moderate	20-40	10-20	5-10
Severe	>40	>20	>10

Bovine Leukemia Virus: Description, Effects, Control

Melvin T. Kuhn, Roger D. Shanks, and Harris A. Lewin

INTRODUCTION

Bovine Leukemia Virus (BLV) is a virus capable of causing a cancer in dairy cattle known as Enzootic Bovine Lymphosarcoma (EBL). It should be noted that bovine leukemia virus is somewhat of a misleading name because the disease caused by BLV is actually lymphosarcoma (a cancer of the lymph glands) and in only 50 percent of EBL cases is there an associated leukemia (a cancer of white blood cells).

Thorough, comprehensive studies have not been done to determine just how many U.S. dairy cows are infected by this virus. Rough estimates, though, suggest that the virus exists in at least 50 percent of all herds. Many agree that this is probably an underestimate. Within a herd, up to 100 percent of all cows may be infected. In short, the virus is not rare, but rather quite prevalent.

The purpose of this article is to: 1) describe the development of the disease caused by BLV; 2) describe the associations between BLV infection and milk and fat yield; 3) discuss the relationship between genetic potential for milk and fat yield and susceptibility to BLV infection; and finally 4) discuss the implications of BLV infection to the dairy producer.

DEVELOPMENT OF DISEASE CAUSED BY BLV

As mentioned above, BLV is associated with the development of a cancer in cattle called EBL. However, upon infection by BLV a cow does not immediately develop a fatal cancer. Instead, the disease progresses in a stepwise fashion and it may become arrested at any particular stage. After being infected, the cow first produces antibodies (proteins whose purpose is to combat infection) against the virus. Cows at this stage are said to be seropositive. Seropositive cows are, in turn, either: 1) normal 2) B cell positive or 3) persistent lymphocytotic (PL). Briefly, these further subdivisions are based on the number of B lymphocytes that an animal has in its blood. B lymphocytes are cells that occur in the blood of all animals and whose purpose is to produce antibodies. It is sufficient to understand that: seropositive normal (or just seropositive), seropositive, B cell positive, and seropositive with PL are simply names for various subclinical stages of the disease and cows may proceed through these stages after infection by BLV. Each stage represents a more advanced or progressed stage than the previous one.

The subclinical stages of BLV infection have no profound effects on the physical well-being of the animal. Cows at these stages can

function normally and do not die from BLV infection. There are no gross physical abnormalities such as extreme weight loss, loss of hair, or unusual bleeding. Nor does fertility, as measured by calving interval, appear to be affected.

Finally, about 1 percent of all infected animals develop the cancer and die. As with other cancers, EBL is characterized by uncontrolled tumor growth. These tumors can occur almost anywhere throughout the body. They are sometimes externally visible in the neck or flank area. They appear as large, unusual growths or swellings. They can also occur in the reproductive tract and, when there, the tumors can often be felt by rectal palpation. Other symptoms that often accompany tumor growth are loss of weight and appetite as well as decreased milk production. Once tumor growth begins, death usually occurs within two months even though cows have survived up to nine months.

It should be noted, that, while the disease may become arrested at a particular stage and never proceed any further, once a cow reaches a certain stage - she does not revert back to former stages either. Thus, once BLV has a foothold within a herd or particular cow, there is little you can do about it except try to prevent future infections.

In regard to BLV infection status, then, cattle are classified as follows:

1. Subclinical Stages of BLV Infection

    a) Seronegative - antibodies against BLV are not present. The animal may or may not be infected but if infected the response to the virus is not detectable. Most cows become seropositive within 3 months of becoming infected.

    b) Seropositive - the animal <u>is</u> producing antibodies against BLV and is therefore definitely infected.

    c) Seropositive, B cell positive - cattle at this stage have an abnormally high percentage of B cells in their blood.

    d) Seropositive with PL - about 30 percent of all BLV infected cows reach this most advanced subclinical stage. Animals have a large and chronic increase in the number of B cells. <u>Animals at this stage are at increased risk for developing tumors</u>.

2. Clinical - Lymphosarcoma (EBL) - tumors resulting in death.

EFFECT OF SUBCLINICAL BLV INFECTION ON MILK AND FAT YIELD AND ASSOCIATION WITH GENETIC POTENTIAL

Research to determine the effect of subclinical BLV infection on milk and fat yield, was recently conducted on 219 Holstein cows

from the University of Illinois dairy farm. The association between subclinical infection status and genetic potential for milk and fat yield was also investigated.

A positive association was found between early BLV infection and milk yield. Seropositive cows outproduced their seronegative herdmates by 1173 pounds. This advantage seems to be lost, though, for cows reaching the PL stage. Milk yields of seropositive with PL and seronegative cows were similar.

Fat yield appears to be depressed by the PL stage. Seropositive with PL cows did not reach their genetic potential for fat yield. Fat percent was also lowest for the seropositive with PL group. BLV infection, then, can be expected to result in lost profit by lost fat yield.

A positive association was also found between genetic potential for milk and fat yield and <u>progression</u> of the disease caused by BLV. That is, cows with higher genetic potential for milk and/or fat were more likely to be seropositive or seropositive with PL than were cows with lower genetic merit for these traits. <u>Why</u> cows with higher genetic potential would be more susceptible to becoming seropositive or seropositive with PL is not known, but is an important question. One possible explanation is that some of the genes that increase milk yield also decrease resistance to BLV. If this is the case, then, as we continue to breed cows for greater milk and fat yield we will also be developing cows that are more prone to subclinical progression of BLV infection. This, in turn, might mean more and more cows being lost to lymphosarcoma (the cancer caused by BLV) and widespread loss of profits due to lost fat yield.

The economic impact of BLV infection in the United States has been estimated at 44 million dollars per year. These costs include death loss, veterinary services, decreased milk yield, and reduced foreign trade of semen and embryos. However, this figure does <u>not</u> take into account lost fat yield which, as indicated by our study, is a significant cost to the U.S. dairy producer.

Finally, older cows are more likely to be seropositive and/or seropositive with PL than are younger cows. It should also be mentioned that the results just discussed need to be verified in other herds and breeds as well. Brown Swiss cattle, for example, show extreme resistance to development of PL.

DETECTING INFECTED COWS

Cows with subclinical BLV infection cannot be identified by mere visual inspection. This requires laboratory analysis of blood samples which can be done by some local veterinarians. This information, though, is of little value unless complete eradication is desired.

MODE OF TRANSMISSION

Any procedure allowing contact of blood between animals could serve as a means of transmitting BLV from cow to cow. Needles, gloves, and dehorning equipment that are used without thorough cleaning could all serve to transmit the virus. There is also proof that BLV is transmitted from dam to calf in the uterus.

ELIMINATING BLV

Immediate and complete eradication would involve identifying all seropositive cows and either slaughtering them or completely isolating them from seronegative herdmates which are costly and difficult processes. Such extreme measures do not seem warranted at this time.

One other possibility to decrease the incidence of BLV infection is to control the transmission of the virus. Changing needles after each injection, and careful cleaning of dehorning equipment would go a long way towards reducing the spread of BLV within a herd.

Two other alternatives for BLV control, that may be accessible in the future, are 1) vaccination against BLV and 2) selective breeding for increased resistance. Unfortunately, a vaccine has not been developed yet and selection for increased resistance needs further investigation.

SUMMARY AND RECOMMENDATIONS

The main points of this article are as follows:

1. BLV is quite prevalent among our dairy cows.
2. It is capable of causing death.
3. The PL stage appears to decrease fat yield.
4. Our study indicates that cows with higher genetic potential for milk and/or fat yield are more susceptible to advanced stages of BLV infection status.

Points two and three clearly indicate that BLV reduces profit. Our main concern is that BLV not be left unchecked in the industry or these costs will become magnified. We certainly recommend taking all possible measures to prevent the spread of BLV. Change needles for each injection and sanitize all equipment which may transmit blood from one cow to another. Failure to follow these relatively simple and inexpensive steps is just inviting spread of the virus. Hopefully a vaccine will soon be developed which will provide us with an effective means of control.

Automation and Engineering Technology for Improved Herd Management

Sidney L. Spahr

Vastly improved technology for milk production has been a major factor in the dairy industry being one of the few farming enterprises which has been consistently profitable during the last decade. Producers receive approximately the same price for milk today as a decade ago (1979 price was $12.00 per cwt) even though expenses, especially for equipment and labor have continued to increase. The industry has remained competitive largely by increased production per cow and increased cows per hour of labor. The resulting increase in efficiency expressed as milk produced per hour of labor is the envy of producers engaged in almost all other types of agricultural production.

TECHNOLOGY DEVELOPMENTS

Technology changes for milk production occurred steadily during the last decade. Automatic detachers were developed in the mid-1970s and became one of the most widely accepted options for parlor automation. Parlors designed for high through-put gradually extended the number of cows that could be milked by one or two operators by incorporating automatic detachers, crowd gates, power entrance and exit gates, rapid exit stalls, and most recently, the side-by-side (right angle) stall design. Some innovations, for example rotary parlors and prep stalls, looked good when they were developed and found a few early enthusiasts, but are rarely selected today due to other technologies being developed which offer more benefits at a lower cost.

UNIVERSITY OF ILLINOIS RESEARCH

Our recent research on dairy automation has focused on four areas: artificial intelligence techniques, electronic estrus detection, new methods for electronic identification, and acquiring body weights automatically.

Two artificial intelligence methods have been studied for possible application to dairy management. In last year's Illinois Dairy Report we reported on IDEA, a natural language interface for extracting data from a dairy database. With it, a user can enter a question about individual animals or groups of animals in the herd using a personal computer with a database about the animals. IDEA can "understand" the question and find the answer from the database. Its understanding is based on dairy herd terminology so that it produces some additional information beyond the specific answer requested.

A second artificial intelligence approach is that of machine learning. This approach uses a "learn-by-example" approach to solving problems. The challenge we gave the program was to describe how to predict the appraised value or the sale price of registered Holsteins. We thought we knew most of the traits that would be important, but there was no way to rate the magnitude and importance of each trait. The artificial intelligence program confirmed that type conformation was very important for elite animals and that production performance and pedigree became more important for those animals that were not elite in type. It provided a new way to combine the importance of various traits in predicting

the value of individual animals. Our work is the first effort of which we are aware to apply machine learning to a dairy management problem.

We have studied two approaches to electronic estrus detection. Both methods show substantial promise, but additional development is necessary before the sensors will be ready for release to the public. In one system a sensor capable of measuring changes in tissue hydration is implanted in the vaginal tissue. It transmits its data to a hand held reader. The longer range goal is to automate the reading of the sensor and to follow the patterns of individual cows on a personal computer. Our work has confirmed the biology of the method (reproduction tissue becomes edematous at estrus due to the action of estrogen), but building a suitable sensor has proven to be a difficult task.

Use of an electronic pedometer is the second electronic method for estrus detection under study. Cattle increase their activity substantially at estrus, usually doubling or tripling their normal activity. We currently are studying a telemetric electronic pedometer. It counts the steps taken by a cow, records them by two hour intervals, and compares them with the cow's previous activity. A major advance in this sensor system was accomplished recently with the development of automatic telemetric acquisition of data using methods similar to those in widespread use on dairy farms for electronic identification. Fine tuning the sensor to make sure that it is actually counting steps by the cow remains to be completed.

A new electronic identification tag designed for attachment to the ear with commercial ear tag equipment is being tested. It can be programmed with a herd number and shows substantial promise for use as both a visual ID for DHI testing and as an electronic number for automatic control of equipment (computer feeder) or acquisition of data (milk meters). It has a nice LED display unit for in-parlor use. Its range of interrogation is about two feet with standard readers, giving it a substantial flexibility for future dairy management applications.

Recent advances in nutrition, especially the development of protein designed to pass undigested from the rumen and be digested in the small intestine (undigested intake protein or UIP), and the widespread use of added fat, either natural or bypass, is resulting in being able to meet a cow's nutrient requirements for higher daily production than previously. These developments, coupled with the pending approval of BST, have resulted in a focus on body weight change or body condition as an important monitor for management decisions. We are currently working on acquiring body weights automatically for cows as they exit the milking parlor. The elements necessary include an electronic ID system, a fast electronic scale, a computer, and an analysis program that is smart enough to separate good weights from bad weights (front of one cow and the back of another one). This system is currently under test with a strategy of obtaining weekly means for each cow.

These elements of dairy automation are being gradually incorporated into an advanced system for herd management - one that will give continuous individual attention by a personal computer to cows housed in a group, thus allowing the manager to take advantage of the labor saving features of group housing while maintaining detailed management of each individual animal.

Table 1. Elements of dairy automation.

Item	Comment
Automatic detachers	Widely accepted to increase cows milked per man-hr in parlors.
Computer feeders	Widely accepted in herds of 50 to 150.
Electronic animal ID	Neck mounted units avialable. Implant units still at prototype stage.
Electronic milk meters, with or without recording	Relatively new, but available from most milking machine companies.
On-farm electronic animal records	Software systems available but expensive.
Electronic selection of AI bulls	Available for Holsteins
Electronic estrus detection	Substantial research in progress; still at prototype stage.
Electronic mastitis detection	Research has stagnated; DHI prostaph test looks more promising in immediate future.
Individual cow ration balancing	Starting to be offered by a few commercial companies and nutrition consultants.
Automatic body weight/condition scores	Under development.
Artificial intelligence analysis and management software	First programs starting to appear for on-farm testing.

The Official DUMPS Testing Program: Report on the First 18 Months

Roger D. Shanks and James L. Robinson

DUMPS, which stands for deficiency of uridine monophosphate synthase, is an inherited disorder that occurs in Holstein cattle. The lethal aspect of the disease is transmitted as an autosomal recessive trait, like pink tooth, mulefoot, or red coat color. As a consequence, each animal has two genes for uridine monosphosphate synthase; most individuals have two normal genes, but carriers have one normal and one undesirable gene. Offspring from mating a carrier animal and a normal animal has a 50 percent chance of being a carrier. Mating a carrier female to a carrier male gives a 25 percent chance of generating an embryo that will be lost around day 40 of gestation and extending the potential calving interval of the carrier female. Due to this deleterious consequence, the Holstein Association of America has declared DUMPS an enzyme defect, that is treated procedurally like any other undesirable recessive. The designation *DP is added to the name of animals identified as carriers, while *TD indicates those tested free of the condition. An official DUMPS testing program has been in effect since January 1988, with our laboratory at the University of Illinois selected to conduct the required analyses. This report covers the first 18 months of the program.

The purposes of the testing program are to identify carriers for this undesirable lethal trait and, just as importantly, to exonerate normal descendants of known carriers. Animals to sample include active and prospective AI sires, ET-donors, and offspring of known carriers. Most bull studs are not accepting carrier bulls into their progeny testing programs. However, some carrier bulls with proofs are remaining active, although their status is indicated on information provided to producers. This leaves the burden of controlling the frequency of the DUMPS gene squarely in the hands of the individual producer. Because of the 25 percent loss after transfer of embryos from carrier-carrier matings, ET-donors chosen for mating to carrier bulls should also be checked. Offspring of known carriers should be tested for DUMPS to identify whether they are normal or carriers, in order to manage their reproduction knowledgeably.

Diagnosis of DUMPS carriers requires unclotted blood samples from the animal of interest and from another of the same age and sex. The latter is used to correct for normal differences due to age and sex, as well as to assess whether samples were damaged before arriving at the laboratory. To minimize the latter possibility, we request that samples be sent by overnight delivery. On arrival, samples are processed and frozen for subsequent biochemical analysis that permits the distinction of normal versus carrier to be made. DUMPS testing kits are available from U. S. and Canadian Holstein Associations, as well as from the Red and White Dairy Cattle Association. In the first year and a half, samples have been received from 34 states and 3 Canadian provinces.

Through June 30, 1989, a total of 1187 blood samples were analyzed, 467 in the first year and 720 in the subsequent six months. A backlog of samples has occurred, as the demand for testing has exceeded our capacity; additional technical personnel have been hired to accommodate the need. Of the animals tested, 230 were shown to be carriers; while twice as many males were sampled, the male-female split among carriers was 60-40. As expected, one half of the offspring of known carriers were normal, while the other half were DUMPS carriers. Over 85 percent of carriers identified were younger than a year of age when sampled; most of these were offspring of Happy Herd Beautician*DP, rated among the top 50 TPI Holstein bulls for the past two years. Early indication of DUMPS status allows the producer to decide on culling and breeding before the animals attain sexual maturity.

Most of the carriers over a year old when tested represent mature Red and White Holsteins from a family not previously known to contain DUMPS carriers. Until late in 1988, all identified DUMPS carriers were relatives of Skokie Sensation Ned. However, at that time, among samples submitted by a bull stud, was that of a Red and White bull that we identified as a carrier; this unexpected result was promptly confirmed on a second blood sample. Analyses of parents, siblings, aunts, and uncles were conducted. While the dam proved to be normal, his sire, Needle-Lane Jon-Red, was shown to be a carrier; consistent with this, 12 of 20 male paternal sibs and 6 of 11 female paternal sibs were also carriers. The sire of Jon-Red is normal based on finding of 13 normal sons and 2 normal daughters. Evidence concerning Jon-Red's dam is inconclusive with an additional normal son and normal daughter. Because Needle-Lane Jon-Red was a highly popular Red and White bull, it is likely that the incidence of DUMPS is higher among Red and Whites than the 1 to 2 percent estimated for U.S. Holsteins.

The embryonic mortality caused by DUMPS is insufficient to control its spread. For example, if carrier sires were used for one generation, the frequency of the lethal gene for DUMPS would rise to 25 percent. If the population was mated at random with respect to DUMPS, it would take 96 generations (roughly 500 years) to reduce the frequency of the gene to 1 percent. However, if all carrier males were identified by a testing program, culled, and not used as sires, only 5 generations (or 25 years) would be required to reduce the frequency to less than 1 percent. Identifying and culling all carriers (male and female) would reduce the incidence in one generation.

We recommend that producers avoid carrier-carrier matings because of the 25 percent embryonic mortality that ensues. That requires identification of DUMPS carriers. We urge that all offspring of known carriers be tested for DUMPS. We applaud the decisions by bull studs to refrain from considering carriers as prospective AI sires. We support the progressive elimination of the undesirable DUMPS gene from the Holstein gene pool, as we do for any inherited disorder in our livestock species.

Added Fat for Dairy Calves Housed in Hutches During the Winter

Edwin H. Jaster, Gene C. McCoy, and Stanislaus L. Lubumbe

Calves have been successfully raised in calf hutches to prevent respiratory disease and avoid problems with humidity and spread of pathogenic organisms. Dairy producers in areas of cold winters have expressed concern about growth and survival of young calves housed in this manner. Weight gains in calves usually are depressed during times of lowest (≤-10°C) and highest (≥20°C) average ambient temperature. Newborn calves also have small amounts of body fat and relatively high energy requirements in relation to body weight. Stress and cold weather increase an animal's need for additional energy. The general practice of rearing replacement dairy calves is to feed a liquid diet consisting of whole milk or milk replacer (reconstituted to 12.5 percent dry matter) at a level of 8 to 10 percent of live weight in two equal feedings. During the milk or milk replacer feeding period, a dry calf starter concentrate mixture is offered free choice. Calves are encouraged to eat small amounts of starter during the first weeks of life. Most large breed calves should be consuming about 1.0 to 1.5 pounds per day of starter by four weeks of age. Achieving adequate growth and survival of dairy herd replacement calves with these recommended feeding programs is important to dairy producers. Recently, in the 1987 Illinois Dairy Report, we reported the addition of energy (fat supplement) to milk or milk replacer improved growth and survival in calves raised in hutches during the winter of 1986. The objective of this study was to determine if higher levels of energy is required to further improve the performance and physiological response of young dairy calves raised in outside hutches during winter.

Forty-five Holstein calves born during December 1, 1987, to March 30, 1988, were assigned to one of three treatments for a 6 week trial starting at day 3 of age. All calves received their dam's colostrum the first 2 days of life and were moved to individual calf hutches with outside feeding at day 2 of age. Dietary treatments were milk replacer (20 percent fat-20 percent crude protein) fed at a rate of 10 percent of body weight in two equal feedings, liquid diet used above with 1/4 pound/day of a fat supplement, and liquid diet used above with 1/2 pound/day of the fat supplement until day 28. The fat supplement contained 62 percent fat (Milk Specialties Inc., Dundee, IL). Half these amounts of milk replacer were fed during week 5, with calves weaned at the end of the 5th week.

Throughout the 6 week experiment, all calves received *ad libitum* a pelleted complete calf starter containing 25 percent alfalfa meal. Starter was formulated to contain 16 percent crude protein. Water was provided free choice. Feed consumption was measured daily throughout the 6 week trial. Calves were weighed at birth, day 3, 7, 14, 21, 28, 35, and 42 of age. Health data on calves included frequency of diarrhea and fecal scores (1-5).

Dry matter intakes of feeds are in Table 1. Similar dry matter intakes of milk replacer (week 1-5) and starter (week 1-3) occurred among treatments. A trend towards reduced intake of starter existed during week 4 in the 1/2 pound/day fat supplemented animals compared to the control calves. The addition of 1/2 pound/day of fat supplement to milk replacer resulted in a 33 percent decrease in starter intake for week 5 and a 23 percent decrease for week 6. No

differences in dry matter intake of milk replacer or starter was detected between calves fed control diet or 1/4 pound/day supplemental fat, week 1-6.

Weekly body weights are in Table 2. Addition of 1/2 pound/day supplemental fat to milk replacer resulted in greater body weight in week 3 and 4 compared to control calves. After discontinuing the fat supplementation at the end of week 4, no differences in week 5 or 6 body weights were detected between groups of calves. The increase in body weight for 1/4 and 1/2 pound/day fat supplemented calves was due to the additional energy supplied to the milk replacer, thus allowing control calves to compensate in growth.

Feed-to-gain ratio and average daily gain are in Table 2. Average daily gain was 18 and 30 percent greater than control animals for 1/4 and 1/2 pound/day fat supplemented calves, respectively. A significant linear effect was detected with addition of 1/4 or 1/2 pound/day supplemental fat added to milk replacer. All groups of calves had similar fecal scores throughout the experiment.

It was more economical to add supplemental fat to milk replacer diets during the first 28 days of the trial (Table 3). The additional cost of feeding calves fat supplement was offset by the additional increase in body weight gain. At the end of 42 days the cost of feeding control calves and 1/4 pound/day supplemented animals was similar. At 42 days, however, the 1/2 pound/day fat supplemented calves cost an additional .10 cents per pound of gain compared to cost of feeding control animals, thus questioning the additional feeding of a 1/2 pound of fat supplement.

In summary, average daily gain of calves was improved when additional fat supplement was fed during the winter in liquid milk replacer. This and other data reflect the need of additional nutrients to calves housed in hutches during cold weather. The feeding of 1/2 pound/day supplemental fat to calves is not recommended based on the reduced intake of starter during weeks 5 and 6. The advantage in average daily gain that the 1/2 pound/day fat supplemented animals had at week 4 compared to controls was lost because of the reduction in starter intake, thus resulting in the loss of body weight gain. Therefore, we recommend feeding 1/4 pound/day supplemental fat to calves housed in hutches during the winter season. Fat supplementation of 1/4 pound/day resulted in better growth rates of calves and possibly better health of animals during early life (day 3 - week 4), especially during cold weather.

Table 1. Dry matter intake of milk replacer and starter.

Measure	Fat supplement		
	Control	1/4 pound/ day	1/2 pound/ day
No. calves	14	12	15
	pound/day		
Milk replacer, dry matter			
Week 1	1.05	1.00	1.04
Week 2	1.10	1.05	1.11
Week 3	1.11	1.11	1.15
Week 4	1.14	1.14	1.19
Week 5	.63	.62	.65
Starter, dry matter			
Week 1	.01	.01	.01
Week 2	.12	.07	.05
Week 3	.23	.15	.14
Week 4	.59	.38	.29
Week 5	1.45	1.11	.96
Week 6	3.47	3.41	2.66

Table 2. Weekly body weight.

Measure	Fat supplement		
	Control	1/4 pound/ day	1/2 pound/ day
	pounds		
Birth weight	94.1	90.2	92.8
Day 3	94.3	92.4	93.9
Week 1	97.2	95.4	98.7
Week 2	98.3	98.1	100.7
Week 3	101.2	100.3	105.6
Week 4	109.1	109.5	114.8
Week 5	117.9	117.7	120.5
Week 6	126.9	126.3	126.5
Average daily gain			
Day 3 - week 4	.56	.69	.80
Day 3 - week 6	.81	.85	.83
Feed/gain			
Day 3 - week 4	2.56	2.28	2.29
Day 3 - week 6	2.34	2.42	2.78

Table 3. Economics of fat supplementation to milk replacers for young calves.*

Measure	Control	Fat supplement 1/4 pound/ day	Fat supplement 1/2 pound/ day
	---------------- dollars	----------------	----------------
Day 3 - week 4			
Milk replacer cost (MR)	19.64	19.20	19.99
Fat supplement cost (F)	0	2.58	5.17
Starter cost (S)	.99	.64	.53
MR + F + S cost per pound gain	1.41	1.25	1.23
Day 3 - week 6			
Milk replacer cost	22.67	22.15	23.12
Fat supplement cost	0	2.58	5.17
Starter cost	6.25	5.48	4.41
MR + F + S cost per pound gain	.89	.88	.99

* Assumed: Cost milk replacer .63¢/pound.
Cost starter .16¢/pound.
Cost fat supplement .40¢/pound.

Susceptibility to Mastitis During the Dry Period

Walter L. Hurley

A high level of management is required to get the most out of a dairy cow's lactation cycle. Part of that management process includes providing a cow with a dry period between lactations. Beginning 45 to 50 days prior to the next expected calving, the cow should be dried-off. Dry periods shorter than 40 days will result in suboptimal milk production in the next lactation, while a dry period of longer than 60 days reduces the total days in milk for the cow's lifetime production. Providing a dry period of optimal length allows the udder to undergo specific structural and functional changes that are necessary for her to produce at the optimal level in the next lactation. During the early stages of the dry period, the gland undergoes a process of involution that takes about three weeks. The process of involution must be completed before the gland starts to undergo the next redevelopment phase that starts three or four weeks prior to the next calving.

The dry period is characterized by rapidly changing susceptibility of the udder to mastitis. Beginning at calving the susceptibility to intramammary infection is reasonably high, but then generally declines as lactation progresses. By late lactation, susceptibility to intramammary infection is fairly low. However, during the first one to two weeks after drying-off, the susceptibility to new intramammary infection increases acutely. During the dry period the secretions in the udder undergo significant changes in composition (Table 1). Many of these compositional changes, as well as other factors, contribute to the decreased resistance to mastitis, particularly during the first few days of the dry period.

After drying-off, milk is no longer being periodically removed from the udder as it was during lactation. Milk volume accumulates in the udder for several days and the pressure build-up often forces the teat to leak milk. In addition, the premilking udder wash and postmilking teat-dip are no longer administered routinely, although continued teat-dipping after drying-off does not seem to reduce the incidence of new intramammary infection. As a consequence, bacteria can easily gain access into the udder during this early dry period. Milk is an excellent growth medium for bacteria and because they are no longer being washed out of the udder two or three times per day, bacteria can grow rapidly and become established in the udder relatively easily.

When an infection occurs in most tissues, a number of disease resistance factors come into play to help combat the infection. Many of these factors are active in the udder when mastitis occurs (see Doane and Hurley, in the 1989 Illinois Dairy Report). However, during the early stages of mammary gland involution, the efficacy of these factors is substantially reduced. The primary defense mechanism is composed of the phagocytic leukocytes that are effective at ingesting and destroying bacteria in most tissues. These leukocytes often are called somatic cells when they are in milk. They include polymorphonuclear neutrophils (PMN) and macrophages that enter the mammary tissue from the blood. In the uninfected udder, the number of leukocytes (somatic cell count) is increasing during early mammary involution, but they may not exceed 500,000 cells/milliliter until several days into the dry period. Furthermore, those leukocytes that enter the secretion are involved in ingesting and degrading the

large amounts of milk components accumulating in the udder. Ingestion of these milk components, particularly milk fat and casein, seems to reduce the ability of the leukocytes to destroy bacteria that they might also ingest.

Immunoglobulins (antibodies) are another component of the immune system involved in resistance to infection. Immunoglobulin concentrations in udder secretions increase in the early dry period, but are relatively low during the first few days. Quantities of antibodies specific for the particular type of bacteria causing the infection may not be sufficient in the udder to effectively neutralize the bacteria. The primary mechanism by which immunoglobulins are involved in resistance against infection is to act as a linker between the bacteria and a phagocytic leukocyte. In early mammary involution the contribution to resistance to infection by both the antibodies and the leukocytes is compromised.

A major nonspecific disease resistance factor is an iron-binding protein called lactoferrin. Bacteria require iron to grow and most bacteria are unable to use iron bound to lactoferrin. During lactation, lactoferrin concentrations in the udder remain low unless an infection occurs. Citrate is a normal component of milk that will chelate iron. Bacteria can use the citrate-bound iron to grow. During early mammary involution, citrate concentrations are high while lactoferrin concentrations are still low, and bacteria that enter the udder have ready access to iron.

All of the above factors combine to result in an increased susceptability to new intramammary infection during the early dry period. Essentially all of the cow's normal means of countering an infection in the udder are compromised. This is why dry-cow antibiotic treatment at drying-off is so important to help her through this early period. Procedures for drying-off a cow that maximize the rate of mammary involution also may be helpful, such as limiting the cow's nutrient intake. Once-a-day milking for several days to a week will initiate the involution process while minimizing the fluid accumulation in the udder, and after milking is halted completely, the tissue will undergo involution faster than normal.

The mid-dry period is the stage of greatest resistance to new intramammary infection compared with any other time in the lactation cycle. By this time there is little fluid volume left in the udder, the teats have become sealed and there is minimal access for bacteria to get into the udder. The composition of the secretion in the udder is more similar to serum than to milk. Phagocytic leukocytes are in high concentrations and there is little of the milk components left to compromise their function in destroying bacteria. Lactoferrin concentrations are high and citrate concentrations are low, so most of the iron in the secretion is not readily accessible to bacteria. Immunoglobulin concentrations also are elevated. If bacteria do manage to enter the udder during this time, the infection is usually taken care of by the cow's own defenses without need for antibiotic treatment.

However, by several days prior to the next calving the udder is undergoing changes that will result in the secretion of colostrum. The picture in the udder is much like that in the early dry period. Large amounts of fluid are accumulating in the udder which may result in leakage from the teats, allowing access of the bacteria to mammary tissue. Teat dipping and periodic milk removal generally are not begun until after calving. Prepartum teat-dipping does not

seem to reduce the incidence of new intramammary infections. Prepartum milking may be beneficial in reducing mastitis at calving, however this potential benefit must be weighted against the loss of colostrum for the newborn calf.

During the prepartum period there are relatively few leukocytes in the secretion and those present are confronted again with increasing amounts of milk fat and casein. Citrate is in high concentrations, while lactoferrin concentrations already have declined two or three weeks earlier. Although immunoglobulin concentrations are increasing even higher during colostrum formation, they still are relatively ineffective in resisting infection. The result is an increased susceptibility to intramammary infection during the prepartum period.

The dry period includes the phases of the lactation cycle when the udder is initially most susceptible and then most resistant to intramammaray infection. Efforts to help the cow through the first week or two of the dry period will minimize the chances of mastitis during the early dry period. Antibiotic dry cow treatment is particularly effective at that time, however, the antibiotic does not remain effective throughout the dry period. Fortunately, during the mid-dry period the cow's own defenses are extremely effective at preventing intramammary infection. The problem again arises in the immediate prepartum period. Good management and hygiene are particularly important at that time to minimize new intramammary infections. Mastitis can occur at any time in the lactation cycle, and even in its most resistant state, the udder is vulnerable to infection.

Table 1. Compositional changes in mammary gland secretions during the dry period.

	Early	Middle	Prepartum
Udder fluid volume	decreasing	low	increasing
Concentrations of:			
Milk components	decreasing	low	increasing
Leukocytes	increasing	high	low
Lactoferrin	increasing	high	low
Immunoglobulins	increasing	high	increasing

Effects of Feeding Alkaline Hydrogen Peroxide-Treated Wheat Straw-Based Diets on Performance of Mid-Lactation Cows

Mark G. Cameron, George C. Fahey, Jr., Jimmy H. Clark, Neal R. Merchen, and Larry L. Berger

Historically, fibrous and byproduct feedstuffs have been somewhat overlooked as dietary ingredients by the U.S. dairy producer. Most fibrous feedstuffs are high in structural carbohydrates (cellulose, hemicelluloses) and lignin and are major underutilized energy resources. The alkaline hydrogen peroxide (AHP) treatment process results in swelling of the cellulose microfibrils and disruption of the cell wall by dissolving some hemicelluloses and lignin. Research at the University of Illinois on the AHP treatment of crop residues has shown increased degradation of cell wall carbohydrates and improved plant cell wall digestion by ruminal microflora. Therefore, AHP-treated wheat straw (WS) may have the ability to partially replace some traditional forages, such as alfalfa haylage (AH) and corn silage (CS), yet maintain optimal feed intake and milk yield in dairy cows. The objective of this trial was to determine the effects of varying dietary levels of AHP-WS on feed intake, nutrient digestibility, milk production, and ruminal fermentation variables when included in a traditional dairy cow diet.

MATERIALS AND METHODS

Wheat straw was treated, using a horizontal mixer-sprayer system, with sodium hydroxide (added at 5.0% of the DM) and hydrogen peroxide (added at 2.0% of the DM). Water was added during the treatment procedure and the final moisture content of the AHP-WS was 35.0%. Eight Holstein cows (four ruminally-cannulated) and averaging 147 days postpartum were used in two replications of a 4 x 4 Latin square design. Fourteen day collection periods were used (9 days for adjustment and 5 days for data collection). Intake and milk production data were collected on the eight cows, while the digestibility and ruminal fermentation data were collected from the cannulated cows. Diets were 1) 37.0% AH, 32.5% CS, 30.5% concentrate (control); 2) 25.9% AH, 23.7% CS, 20.0% AHP-WS, 30.4% concentrate (low); 3) 15.7% AH, 13.9%CS, 40.1% AHP-WS, 30.3% concentrate (medium); and 4) 5.2% AH, 4.6% CS, 60.0% AHP-WS, 30.2% concentrate (high). The concentrate mixtures for the diets contained varying amounts of ground corn, soybean meal, minerals, and vitamins to meet the nutrient requirements of the cow. Diets were balanced to contain at least 16.0 percent CP and 21.0 percent acid detergent fiber.

Dry matter (DM) intake and milk production were recorded daily. Milk composition was determined from milk samples taken twice daily on days 11 and 12 of each collection period. Ruminal fluid samples were collected hourly for 24 hours on day 14 of each period and analyzed for ammonia-N, pH, and volatile fatty acids (VFA). Apparent digestibilities of the diets were determined by using chromic oxide as the marker.

RESULTS

Dry matter intakes were highest on the control and low AHP-WS treatments, 52.0 and 52.5 pounds per day, and decreased linearly (P=.02) to 47.0 pounds per day for medium and 42.5 pounds per day for the high AHP-WS treatment (Table 1). There were no effects on apparent DM digestibility with increased levels of AHP-WS in the diet; however, DM digestibility was lowest on the high AHP-WS treatment

at 63.8 percent. There was a quadratic trend (P=.16) for NDF intake with animals consuming 17.6 pounds per day on the control diet and increasing to 18.6 to 19.6 pounds per day on the AHP-WS treatments. Apparent NDF digestibility increased linearly (P=.03) with increasing dietary AHP-WS level (control digestibility of 44.4 percent), with 10.2, 12.1, and 14.9 percentage unit increases for low, medium, and high AHP-WS treatments. It appeared that the NDF fraction of the AHP-WS-containing diets was more rapidly and extensively degraded in the gastrointestinal tract as compared to the control diet.

The increased level of AHP-WS fed in the diet had numerous effects on milk production and the various milk components (Table 1). Linear and quadratic effects (P=.0001) were noted for milk yield and 4% FCM (pounds per day) with similar production responses between the control and low AHP-WS treatments. Cows fed medium and high-AHP-WS diets had lower daily milk yields, 2.2 and 7.5 pounds per day decreases when compared to the low AHP-WS diet (59.3 pounds per day). This decrease in milk yield could be attributed to lower DM intakes by cows fed the medium and high AHP-WS diets. Milk fat percentage decreased linearly (P=.002) with increased levels of AHP-WS (from 3.72% for the control to 3.60% for the high AHP-WS treatment). Milk protein decreased linearly (P=.0001) from 3.27% for control to 3.13% for the high AHP-WS diet.

Effects of the diets on ruminal pH, VFA, and ammonia-N are shown in Table 1. Increased levels of AHP-WS in the diet did not have an effect on ruminal fluid pH, with values of 6.14 for the control treatment and 6.17 for the AHP-WS-based treatments. The addition of varying levels of AHP-WS resulted in a linear response (P=.0001) in total VFA concentration of 128.0, 131.1, 131.2, and 136.0 mM for control, low, medium and high AHP-WS treatments. It appears that inclusion of AHP-WS in the diets resulted in a rapidly fermented feed and that fiber digestion was not hindered, as the NDF digestibility increased with the addition of dietary AHP-WS.

Molar percentage of acetate increased linearly (P=.0001), while there was a quadratic effect (P=.0001) with molar percentage of propionate and the molar ratio of acetate to propionate (A:P) with increased levels of dietary AHP-WS (Table 1). The acetate, propionate, and A:P values indicate that increased AHP-WS levels resulted in the formation of end-products which are associated with fiber digestion. However, the low DM intakes for the medium and high AHP-WS treatments may have resulted in VFA production that was less than optimal for maximal milk fat synthesis, as milk fat percentages decreased when compared to the control and low AHP-WS diets.

Ammonia-N concentrations decreased linearly (P=.0001) from 15.1 mg/dl for the control to 13.7, 11.4, and 11.0 mg/dl for the low, medium, and high AHP-WS treatments, respectively. The higher ammonia-N concentration in the control treatment could be explained by the release of ammonia-N from the rapidly fermented AH, fed at 37.0 percent of the diet.

Results of this trial demonstrate that mid-lactation dairy cows responded favorably to low levels of AHP-WS in the diet as compared to a traditional diet containing AH and CS. Cows fed the low AHP-WS level had similar DM intakes and yields of 4% FCM. However, it appears that high levels of AHP-WS (60.0 percent) in the diet may depress DM intake and reduce milk production.

Table I. Least squares means for intake, apparent digestibility, milk variables, and ruminal fermentation criteria.

Item	Treatment	AHP-WS level[1]			SEM
	Control	Low	Medium	High	
Intake, lb/d					
DM	52.0	52.5	47.0	42.5	2.34
NDF	17.6	19.6	19.2	18.6	.79
Digestibility, %					
DM[2]	66.0	69.0	65.9	63.8	2.27
NDF[2]	44.4	54.6	56.5	59.3	4.16
Milk yield, lb/d	59.3	59.3	57.1	51.8	.55
4% FCM, lb/d	56.6	56.9	54.2	48.5	.62
Milk fat, %	3.72	3.75	3.69	3.60	.03
Milk protein, %	3.27	3.21	3.17	3.13	.01
Solids-not-fat, %	8.10	8.12	8.06	8.13	.03
pH	6.14	6.17	6.17	6.17	.02
VFA[2], mM	128.0	131.1	131.2	136.0	1.22
VFA, molar %					
Acetate	64.9	65.8	66.7	69.2	.11
Propionate	17.9	18.9	18.7	18.2	.07
Butyrate	12.1	11.1	11.2	10.0	.07
Acetate: propionate ratio	3.6	3.5	3.5	3.8	.02
Ammonia-N mg/dl	15.1	13.7	11.4	11.0	.62

[1] Level of AHP-WS in control diet = 0%, low = 20.0%, medium = 40.1%, and high = 60.0%.

[2] DM = dry matter, NDF = neutral detergent fiber, VFA = volatile fatty acids.

Feeding Alkaline Hydrogen Peroxide-Treated Oat Hull-Based Diets to Mid-Lactation Dairy Cows

Mark G. Cameron, George C. Fahey, Jr., Jimmy H. Clark,
Neal R. Merchen, and Larry L. Berger

Lactating dairy cows have the ability to ingest diets that are relatively high in forages and roughages; however, the lower digestibility and rate of passage of high fiber diets often restrict intake. As cereal grains increase in demand for direct human use, alternative energy feeds will be used increasingly for dairy production. Despite the large amounts of oat hulls (OH) available each year, they have not been studied as a component of dairy cattle diets to any great extent. One reason for this lack of interest in OH as feed is that the net energy for lactation is lower than for feeds like alfalfa haylage (AH) or corn silage (CS). Oat hulls are low in crude protein (3.9 percent) and relatively high in structural carbohydrates (NDF of 78 percent, ADF of 42 percent) with a lignin content of 8 percent. However, alkaline hydrogen peroxide (AHP)-treatment of OH appears to disrupt the cell wall and make the lignocellulosic material more susceptible to degradation, thus improving the digestibility and nutritive value of OH. The objective of this trial was to determine the effects of varying levels of AHP-OH on feed intake, nutrient digestibility, milk variables, and ruminal fermentation when compared to an AH and CS-based diet.

MATERIALS AND METHODS

Twelve Holstein cows (four ruminally-cannulated) and averaging 110 days postpartum were used in three replications of a 4 x 4 Latin square with 14 day periods (9 days for adjustment and 5 days of data collection). Intake and milk production data were collected from all cows, with digestibility and ruminal fermentation data collected from the cannulated cows. Diets were 1) 32.7% AH, 32.3% CS, 35.0% concentrate (C)(control); 2) 24.0% AH, 23.7% CS, 17.2% AHP-OH, 35.1% C (low); 3) 15.2% AH, 15.0% CS, 34.5% AHP-OH, 35.3% C (medium); and 4) 6.3% AH, 6.2% CS, 52.1% AHP-OH, 35.4% C (high). The concentrate mixtures for the diets contained varying amounts of ground corn, soybean meal, minerals, and vitamins to meet the nutrient requirements of the cow. Diets were balanced to contain at least 16.0 percent CP and 21.0 percent ADF.

Dry matter intake and milk production were recorded daily. Milk composition was determined from milk samples taken twice daily on days 12 and 13 of each period. Ruminal fluid samples were collected on day 14 of each period and analyzed for ammonia-N, pH, and volatile fatty acids (VFA). Apparent digestibilities of the diets were determined by using chromic oxide as the marker.

RESULTS

Dry matter intake was lowest for the control diet (54.2 pounds per day) and increased by 5.5, 6.9, and 3.8 pounds per day, respectively, for the low, medium, and high AHP-OH diets (Table 1). The quadratic increase in DM intake (P=.03) resulted in a nonsignificant decrease in apparent DM digestibility from 68.7 percent for the control diet to approximately 67.0 percent for the AHP-OH-containing diets. The addition of AHP-OH to the diet resulted in both a linear increase in NDF intake (P=.0002) and NDF digestibility (P=.02). Neutral detergent fiber intake was 15.7 pounds per day for the control diet and increased

6.7, 10.7, and 11.4 pounds per day, respectively, for the low, medium, and high AHP-OH diets. There was a 15.6 percentage unit increase in NDF digestibility between the control and the high AHP-OH diet (43.2 percent versus 58.8 percent). Therefore, it appears that the AHP treatment of OH resulted in an NDF fraction that was rapidly and extensively degraded in the gastrointestinal tract.

A quadratic effect (P=.005) in milk production was noted as level of dietary AHP-OH increased. Milk yield was 2.6 and 2.4 pounds per day higher for the low and medium AHP-OH diets when compared to the control diet, yet milk fat percentages were highest for the AHP-OH diets. This resulted in greater 4% fat-corrected-milk yields for the AHP-OH-containing diets as compared to the control diet. However, increasing the level of dietary AHP-OH resulted in a linear decrease (P=.0001) in milk protein percent.

Level of AHP-OH resulted in a linear effect (P=.0001) on ruminal pH. The ruminal pH was 5.87 for the control diet and increased to 6.12 for the high AHP-OH diet. Research has shown that higher ruminal pH will result in optimal fiber digestion and the data in Table 1 indicate that NDF digestibilities were higher for cows fed the AHP-OH diets as compared to the control diet. When the AHP-OH diets were consumed by cows, the molar percentage of acetate was linearly increased (P=.0001) and the molar percentage of propionate was linearly decreased (P=.0001), resulting in a linear increase (P=.001) in the molar ratio of acetate to propionate (A:P). The VFA values indicate that increased levels of AHP-OH in the diet resulted in the formation of end-products which are associated with fiber digestion which may allow for an increase in milk fat synthesis. This was evident as the milk fat percentage was 3.53 percent for the control diet and increased to approximately 3.63 percent for the AHP-OH diets (a linear trend at P=.18).

Ammonia-N concentrations were lowest on the medium and high AHP-OH treatment and increased as the level of AHP-OH was decreased in the diet. The higher ammonia-N concentration for the control diet may be attributed to the high amount of AH, which is rapidly fermented and resulted in increased release of ammonia-N.

Results of this trial suggest that lactating dairy cows fed increasing levels of AHP-OH in the diet had significantly greater intakes and milk production responses when compared to cows fed the control diet. There was a trend towards improved milk fat percentage which could be attributed to fermentation end-products that resulted from an increased NDF digestibility by cows fed AHP-OH-based diets.

Table 1. Least squares means for intake, apparent digestibility, milk variables, and ruminal fermentation criteria.

Item	Treatment				
		AHP-OH level[1]			
	Control	Low	Medium	High	SEM
Intake, lb/d					
DM[2]	54.2	59.7	61.1	58.0	1.23
NDF[2]	15.7	22.4	26.4	27.1	.92
Digestibility, %					
DM	68.7	67.0	66.8	67.4	1.64
NDF	43.2	46.2	50.5	58.8	3.34
Milk yield, lb/d	73.4	76.0	75.8	72.5	.97
4% FCM[2], lb/d	67.9	71.6	71.4	68.3	1.01
Milk fat, %	3.53	3.63	3.62	3.63	.05
Milk protein, %	3.19	3.20	3.16	3.07	.02
SNF, %	8.05	8.11	8.03	8.04	.05
pH	5.87	5.96	5.96	6.12	.02
VFA[2], mM	124.4	126.2	124.1	115.1	1.22
VFA, molar %					
Acetate	60.4	63.1	64.2	67.7	.19
Propionate	23.7	21.3	20.6	19.0	.14
Butyrate	11.6	11.8	11.2	9.4	.11
Acetate:propionate ratio	2.62	3.03	3.17	3.61	.02
Ammonia-N, mg/dl	10.0	9.4	8.4	8.8	.51

[1] Level of AHP-OH in low = 17.2%, medium = 34.5%, and high = 52.1%.
[2] DM = dry matter, NDF = neutral detergent fiber, FCM = fat-corrected milk, SNF = solids-not-fat, and VFA = volatile fatty acid.

Alfalfa Haylage-Alkaline Hydrogen Peroxide-Treated Wheat Straw Combinations Fed to Dairy Heifers

David G. Atwell, Neal R. Merchen, Ed H. Jaster, George C. Fahey, Jr., and Larry L. Berger

The efficacy of the alkaline hydrogen peroxide treatment process to increase both the intake and digestibility of wheat straw when compared to native wheat straw is well documented. However, evidence exists that both intake and digestibility of alkaline-treated crop residues may be further enhanced when fed with relatively small amounts of a high quality roughage such as alfalfa. The mechanism by which alfalfa improves utilization of alkaline-treated crop residues may reside in its complementary nature. Treated crop residues such as alkaline hydrogen peroxide-treated wheat straw (AHP-WS) are generally low in calcium (Ca), phosphorus (P) and ruminally degradable protein. Alfalfa, on the other hand, is a relatively good source of these nutrients. Additionally, alfalfa is generally well accepted by ruminants. Feeding these two forages together may improve the utilization of the AHP-WS.

Dairy heifers are typically fed high forage diets and represent a good target species for the feeding of AHP-WS-alfalfa combinations. An experiment was conducted to study the effects of feeding combinations of AHP-WS and alfalfa haylage on dry matter intake (DMI) and total tract digestibilities [DM, organic matter (OM), crude protein (CP), NDF and ADF].

PROCEDURE

Twelve Holstein heifers weighing approximately 730 pounds (4 animals fitted with permanent ruminal cannulas, 8 intact animals) were used as experimental animals in 3 replications of a 4 x 4 Latin square. Experimental diets (Table 1) consisted of an 80:20 forage to concentrate ratio (dry matter basis). Dietary designations were based on dry matter (DM) ratios of AHP-WS:alfalfa haylage in the diet: 80:0, 80% AHP-WS and no alfalfa haylage; 53:27, 53% AHP-WS and 27% alfalfa haylage; 27:53, 27% AHP-WS and 53% alfalfa haylage; 0:80, no AHP-WS and 80% alfalfa haylage. Diets were balanced to meet or exceed requirements for CP, Ca, P, potassium, trace minerals and vitamins A, D and E. Diets were fed twice daily at 0800 and 2000 in equal portions at a level to ensure 10 percent feed refusal.

Experimental periods were 21 days in length with a 14 day adaptation phase followed by a 7 day collection phase. Dry matter intake was calculated as the mean intake for day 12 through day 21. Animals were bolused with chromic oxide twice daily at 12 hour intervals beginning on day 8 through day 21 of each period. Fecal grab samples were collected twice daily on day 15 through day 20 in a sampling scheme such that a sample was taken at each 1 hour interval between the morning and evening feeding. An aliquot of each sample was composited by animal and period for subsequent analysis. Samples of feed, orts and feces were analyzed for DM, OM, Kjeldahl N, NDF, and ADF. Fecal DM output was determined with reference to chromic oxide in order to determine total tract digestibilities for DM, OM, Kjeldahl N, NDF and ADF. Animals were weighed on the first day of each period and the last day of the last period.

RESULTS

The effect of experimental diets on intake and digestibility of dietary components is presented in Table 2. There was a significant quadratic effect due to diet for DMI expressed as either pounds per day or percent of body weight. Intake increased above that seen on the high AHP-WS diet (80:0) by 12 percent when alfalfa was substituted for AHP-WS at the 27 percent level. Intakeincreased another pound per day when alfalfa comprised 57 or 80 percent of diet DM. This same quadratic increase ($P<.05$) was noted for OM intake. Intake of OM appeared to be maximized when alfalfa comprised between approximately 30 and 50 percent of diet DM. Crude protein intake increased quadratically ($P<.05$) with increasing CP concentration in the diet. Intake of NDF and ADF decreased quadratically ($P<.05$) with decreasing level of AHP-WS.

The apparent digestibility of DM decreased linearly ($P<.05$) with decreasing level of AHP-WS in the diet. This result is probably due to the high digestibility of sodium in the ash component of the AHP-WS. Additionally, the fiber fraction of AHP-WS is more digestible than that found in the alfalfa. Organic matter digestibility was unaffected by diet averaging about 64 percent of all diets. Crude protein digestibility responded in a cubic manner ($P<.05$) due to diet, demonstrating no consistent pattern among the diets. The apparent digestibility of both NDF and ADF demonstrated a linear decrease ($P<.05$) with decreasing level of AHP-WS in the diet. This effect on fiber digestibility has been demonstrated in other studies conducted at this laboratory and reemphasizes the highly digestible nature of WS fiber subsequent to the treatment process.

In conclusion, positive associative effects between AHP-WS and alfalfa haylage were noted for intakes of DM and OM. It appears that intakes may be maximized when alfalfa comprises between 30 and 50 percent and AHP-WS, between 50 and 30 percent of diet DM. While intake was improved by the addition of alfalfa haylage, it is also important to note that heifers on the high WS diet had DMI of 18 pounds per day. This intake level would be adequate to sustain acceptable growth rates for replacement heifers. Intakes of CP, NDF and ADF were predictable given the pattern of DMI and the dietary concentrations of these fractions. Positive associative effects for digestibility of DM and OM were not observed. The digestibility patterns observed for NDF and ADF are reflective of the less refractory nature of these fractions in AHP-WS when compared to alfalfa. This study demonstrates that AHP-WS either alone or in combination with alfalfa haylage is an entirely suitable feed for growing dairy heifers.

Table 1. Ingredient and chemical composition of experimental diets fed to dairy heifers.

Item[a]	Diets 80:0	53:27	27:53	0:80
Ingredient				
AHP-WS	80	53	27	
Alfalfa haylage		27	53	80
Urea	1	1	1	1
Corn gluten meal	9.2	1.6		
Ground corn	8.5	16.5	18.3	18.3
Dicalcium phosphate	.72	.55	.35	.35
Calcium sulfate	.23			
Mineral and vitamin mix	.35	.35	.35	.35
Chemical composition				
Dry matter	65.7	64.3	63.4	62.4
Organic matter	86.2	87.8	89.0	89.9
Crude protein	12.9	13.6	17.5	22.5
NDF	53.5	47.4	41.9	36.0
ADF	36.8	32.3	27.6	23.3

[a] Ingredient and chemical composition are expressed as a percentage of diet DM.

Table 2. Effect of feeding differing combinations of alkaline hydrogen peroxide-treated wheat straw (AHP-WS) and alfalfa haylage on nutrient intake and digestibility by dairy heifers.

Item[a]	Diets 80:0	53:27	27:53	0:80	SE[a]
Intake					
Dry matter, lb/d[b]	18.3	20.5	21.6	21.6	.37
Dry matter, % of body weight[b]	2.26	2.54	2.67	2.67	.043
Organic matter, lb/d[b]	15.4	17.6	18.7	19.0	.35
Crude protein, lb/d[b]	2.4	2.9	3.7	4.8	.09
NDF, lb/d[b]	9.5	9.7	8.8	7.5	.18
ADF, lb/d[b]	6.6	6.6	6.0	4.8	.11
Digestibility, %					
Dry matter[c]	65.4	64.4	63.0	61.5	.49
Organic matter	64.5	63.6	63.3	63.1	.55
Crude protein[d]	60.4	55.8	60.4	63.7	.93
NDF[b]	68.3	62.3	54.5	43.1	.82
ADF[b]	68.1	61.4	51.2	37.1	1.00

[a] Standard error or the mean.
[b] Quadratic effect of diet (P<.05).
[c] Linear effect of diet (P<.05).
[d] Cubic effect of diet (P<.05).

Effects of Fat Feeding on Milk Protein

Carl L. Davis

There is a national trend toward the pricing of fluid milk on components other than fat or at least in addition to fat. This move is long overdue because fat is the least desirable component of the milk. Protein is by far the most important component of milk because of its nutritional properties. The importance of milk proteins in cheese making and in providing the protein base for milk replacer formulations for both humans and young animals is well established. The recent discovery that milk proteins can be modified chemically to behave physically like and taste like fat will increase their usage in creamers, candies, ice cream, etc., thereby adding to the demand in a market which is currently tight on the supply side. As emphasis is placed on protein in the pricing of milk, how can the producer assure the best market price for the milk sold?

Factors which are known to affect the protein content of milk are genetics, stage of lactation, environmental temperature, and feeding (ration makeup and level of feeding). This report deals only with the effects of feeding on protein content of the milk because this is the area where immediate changes can be made to assure that the genetic potential of the cow is being expressed in milk protein production. In the long term, more attention should be given to selecting breeding stock with the potential for the production of milk of higher protein content.

Within the realm of feeding, there are a number of situations which affect the protein content of the milk produced. These are listed in Table 1. Before discussing these factors, a few points need to be emphasized. First, the variation in milk protein content is much less than seen with milk fat. Second, very few studies have been designed specifically to look at the effects of a particular feeding practice on milk protein content. Thus, we are forced to glean information about the effects of certain diets on milk protein content from studies designed for other purposes. In so doing, the results may be confounded by more than one factor. This, no doubt, contributes to the wide variation in responses seen in the data to be presented later.

Before getting into the main thrust of this discussion, which will center upon the effects of fat feeding on milk protein content and yield, a few general remarks need to be directed toward other important feeding practices. It has long been recognized that underfeeding on energy and protein will reduce the protein content of the milk as well as the yield of protein. The greatest effect of underfeeding of either energy or protein will be on milk yield rather than on milk composition. Increasing energy intake of cows that are in a negative energy balance by providing additional grain in the ration (up to a maximum of 60:40 grain to forage ratio, fed *ad libitum*) will result in a higher protein content of the milk as well as total yield of milk protein. The dietary protein needed to maximize milk protein content is thought to be in the realm of 15-

17 percent crude protein (dry basis). Expressing crude protein requirements as a percent of the dry matter of the ration is fine so long as the following conditions are met: 1) the diet is highly acceptable to the cow; 2) the supplemental protein added is true protein (soybean meal, cottonseed meal, or corn gluten meal) and not non-protein nitrogen (urea); and 3) some (30-40 percent) of the supplemental protein is resistant to breakdown in the rumen (by-pass protein).

EFFECT OF FAT FEEDING ON MILK PROTEIN

In an effort to increase energy intake of lactating cows in early lactation, it is becoming a general practice to supplement the diet with fat, either in the form of whole oil seeds (cottonseeds, soybeans, or sunflower seeds) or special high fat supplements. The latter will be described later on in the discussion. Generally speaking, increases in either milk yield or fat test or both have been seen by feeding extra fat to cows in early lactation. However, the protein content of the milk produced by cows fed the fat supplemented diets is often depressed below that of cows fed the control diet. This is the subject of the remainder of this article.

The degree to which fat feeding affects milk protein content and yield appears to be influenced by a number of factors. Two of these factors will be dealt with below. First, the level of fat feeding certainly is an important factor and is most clearly demonstrated within a particular study when increasing amounts of the same fat source is substituted into a common basal ration. Data in Figure 1 show that increasing the consumption of a ruminally inert fat results in a decrease in milk protein content. Researchers have reported that the protein content of milk is reduced 0.02-0.03 percentage units per 100 grams (.22 pounds) of supplemental fat consumed. Thus, if one pound of supplemental fat is fed per cow per day, a decrease of from 0.1 to 0.15 units in milk protein is likely to occur.

The second factor, relating to the degree to which fat affects milk protein content and yield, is the source of the fat and possibly its makeup. Although not as clear cut as that for the effects of level of fat as exemplified in Figure 1, the trend of the data seem to support the above statement. In this article, fat sources have been placed in one of two broad catagories; e.g., those supplied in the form of whole oil seeds (cottonseed, soybean and sunflower seeds) and others as high fat supplements (tallows, protected and unprotected; blended fats, animal and vegetable blends; calcium salts of fatty acids, Megalac™, and prilled fatty acids, Energy Booster™). Differences appear to exist with regard to how the lactating cow responds to the fats in these two catagories. The research findings are examined in detail in the following sections.

EFFECTS OF FEEDING WHOLE OIL SEEDS ON MILK PROTEIN

Summation of research findings from many studies complicates interpretation because of the vast differences existing between experiments with regard to level of feeding, type of diet, length of the trial, number of animals per experimental unit, and production level of the animals as well as stage of lactation. No doubt, much of the variation seen in the data set can be attributed to the above differences in experimental procedures.

Data in Figure 2 show changes in milk protein content when varying amounts of whole oil seeds (cottonseed and soybeans) were fed to dairy cows. Of the 26 observations, 13 were significantly ($P<.05$) lower as a result of feeding whole oil seeds while none were significantly higher. The degree of depression of milk protein content by feeding of whole oil seeds does not seem to be related to the amounts fed or to the kind (cottonseed *vs* soybeans). Although not shown, heat treatment of the whole oil seeds does not appear to alter their effect on the production performance of the lactating cow (milk yield, fat test, milk protein content) compared to whole raw seeds.

If the price of milk is tied to protein content, income from the sale of milk may not suffer from fat feeding if the change in ration results in a higher milk yield. Data summarized in Figure 3 show the effects of feeding whole oil seeds on milk yield. Variation in the data set is much greater than that seen with the effects of whole oil seed feeding on milk protein content. Of the 41 observations reported on milk yield, only 3 showed a statistically significant ($P<.05$) increase in milk yield and that was from feeding whole soybeans. I think it fair to conclude that the feeding of whole oil seeds will not result in significant changes in milk yield. Here, as shown with the effects of whole oil seed feeding on milk protein content, there doesn't seem to be any relationship between milk yield and the amount of whole oil seed consumed.

Since milk yield and milk protein percent do not show a significant relationship to intakes of whole oil seeds, I simply plotted milk yield versus milk protein production and calculated a line of "best fit" to the data points for both control and whole oil seed-fed cows. These data are in Figure 4. What is to be concluded from this graph? 1) Since the two lines are almost identical, the effect of feeding whole oil seeds on milk yield and milk protein percent are minimal. 2) From the slopes of the two lines, one can calculate the amount of milk necessary to yield a given quantity of milk protein. This has been done for the production of 1000 and 1200 grams of milk protein and the results are given in Table 2. Note that the differences between the control and treated (fed whole oil seeds) groups are very small with reference to milk required and milk protein percent at both levels of milk protein production (1000 and 1200 grams/day). I interpret this to indicate that even though milk protein percent is depressed by whole oil seed feeding, there is enough of an increase in milk yield (although not statistically significant) to compensate so that total protein yield is essentially unaltered by the feeding of whole oil seeds.

EFFECT OF FEEDING HIGH FAT SUPPLEMENTS ON MILK PROTEIN

There are a number of high fat supplements on the market. They vary widely in their makeup both chemically and physically. The intact fats are tallow based or blends of animal and vegetable fats. Some of these have been severely hydrogenated (saturated) to render them inert in the rumen, while others are unaltered. Two special fat supplements (Energy Booster™ and Megalac™) are blends of fatty acids. The fatty acids in Megalac™ are rendered ruminally inert by preparing the calcium salt (soap) of the fatty acids, whereas, Energy Booster™ relies upon the prilling of specific blends of fatty acids to provide the protection needed in the rumen. Most of the data summarized in this report are from studies with Energy Booster™ and Megalac™ because they have been the most thoroughly tested products. The results from a few studies involving the use of "protected" tallow have been included for comparative purposes. "Protected" tallow as reported here is a product in which the fat was coated with

a protein and this treated with formaldehyde. This product is not available commercially because of FDA prohibition on the use of formaldehyde in the preparation of feeds for livestock.

What effect do the high fat supplements have on the protein content of milk produced? A summary of research findings is in Figure 5. There definitely is a reduction in the protein content of the milk produced but as seen with the feeding of whole oil seeds, the extent of the depression does not appear to be related to the amount of fat consumed. The lack of a clear relationship is not too surprising when considering the vast differences in makeup of the basal rations, level of production, and stage of lactation of the cows used and the makeup of the fats fed.

As pointed out earlier, a drop in milk protein content may not result in a decrease in income from milk sales provided the ration change stimulates higher milk production. Data in Figure 6 show the effects of feeding the high fat supplements on milk yield compared to that of the control cows. Although variable, the change in milk yield is more positive than seen with the feeding of whole oil seeds. A lot of the variation can be accounted for by the use of low producing cows. Of the 10 statistically significant increases seen in milk yield, 8 were for cows producing in excess of 30 kg (66 pounds) of milk per day. The average increase in milk for the cows in this group was 2.1 kg (4.61 pounds) per day.

When milk yields are plotted against yields of milk protein for both the control cows and those receiving the supplemental fats, a pattern develops which is different from that seen with the feeding of whole oil seeds. The two mathematically derived lines converge at about 48 pounds of milk (approximately 700 grams of protein) suggesting that at this level of production, fat supplementation was without effect on milk yield and protein content of the milk. However, from this point, as milk production increased, the protein content of the milk of the fat-supplemented cows declines much more than for the control cows. Just as was done with the data form the whole oil seed studies, the slopes of the lines were used to calculate the amounts of milk required to yield two quantities (1000 and 1200 grams) of protein. These data are given in Table 2. There are two things to note: 1) Compared to the feeding of whole oil seeds, more milk is required to yield a given quantity of protein, thus, indicating that the milk from cows fed the high fat supplements has a lower protein content than that from cows fed whole oil seeds. This may not hold true for individual fats. 2) As the level of milk production increases, a greater depression in milk protein occurs with the high fat supplements.

If we had stopped at this point someone would surely conclude that high fat supplements should not be fed when the milk price is based on protein content. Well, let's take a closer look at the economics. For illustration, the base price of milk is set at $11.00/cwt with a protein content of 3.10 percent. The differential for milk protein is 10 cents per 0.1 unit change from 3.10. As pointed out earlier, cows producing in excess of 30 kg (66 pounds) of milk showed an average increase in milk of 2.1 kg (4.6 pounds) per day. Let's assume that the control cows (unsupplemented ration) were producing 35 kg of milk (77 pounds) per day with a protein content of 3.1 percent and that adding a pound of an acceptable fat to the ration boosted milk yield 2.0 kg per day (37 kg or 81.4 pounds). However, the protein content of the milk was reduced to 2.95 percent. The average daily income from the sale of milk from the control cows would be

$8.47/cow/day (77 x $11.00/cwt); whereas, the value of the milk from the cows getting the fat supplement would be $8.83/cow/day (81.4 x $10.85/cwt). Each producer will have to evaluate the economics of fat feeding in their herd with an eye on changes in milk protein percent and milk yield as a result of the change in the ration. The positive benefits derived from fat feeding in early lactation seem to greatly outweigh the one negative effect of a small but significant decrease in milk protein percent.

Table 1. Dietary factors affecting the protein content of milk produced.

Dietary factors	Effect on milk protein content
Underfeeding on energy	decrease
Underfeeding on protein	decrease
Feeding diets high in fiber	decrease
Feeding diets containing whole oil seeds	decrease
Feeding ration with increasing grain, up to 60:40 grain:forage ratio	increase
Feeding diets containing supplemental fats	decrease
Supplementing niacin to the diet	variable

Table 2. Calculated responses to the feeding of whole oil seeds and high fat supplements using data from Figures 4 and 7.

Source of fat	Expt. groups	Yield of milk protein (grams)	Amount of milk required (lb)	Differences in milk (lb)	Milk protein (%)	Difference in milk protein (%)
Whole oil seeds	Control	1000	70.6		3.12	
	Treated	1000	71.3	.7	3.09	0.03
	Control	1200	86.9		3.04	
	Treated	1200	87.1	.2	3.02	0.02
High fat supplements	Control	1000	72.2		3.05	
	Treated	1000	74.8	2.6	2.94	0.11
	Control	1200	88.4		2.99	
	Treated	1200	92.8	4.4	2.84	0.15

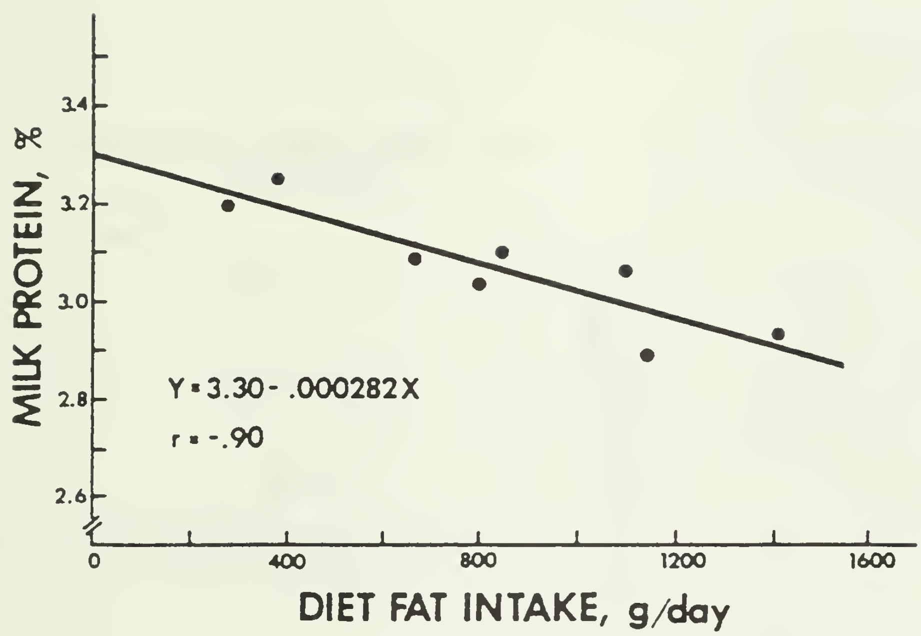


Figure 1. Relation between diet fat intake and milk protein concentration (Data from Bines et al., J. Agric. Sci. 91:135, 1978)

Fig. 2 Effect of Feeding Whole Oil Seeds
on Protein Content of Milk Produced

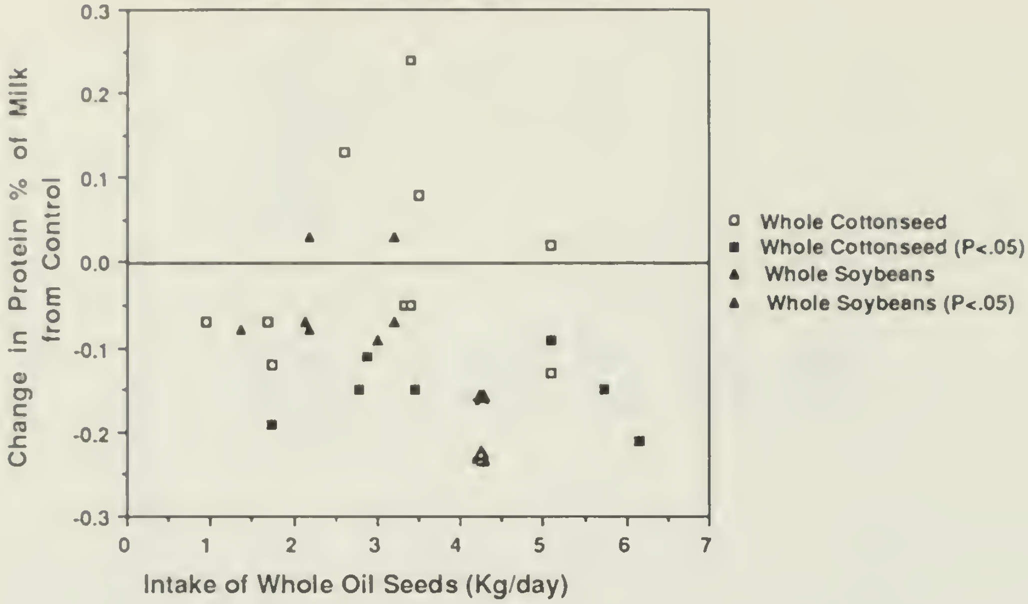


Fig. 3 Effect of Feeding Whole Oil Seeds
on Milk Yield

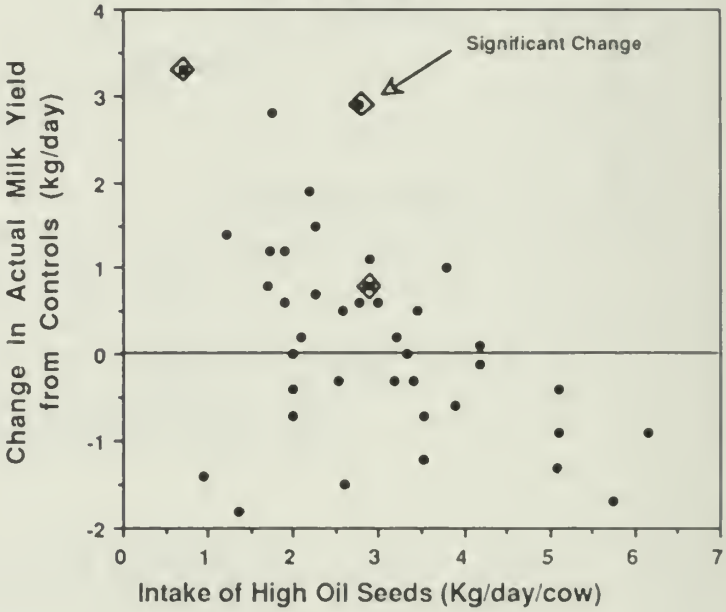


Fig. 4 Effect of Feeding Whole Oil Seeds
on Milk Protein Yield

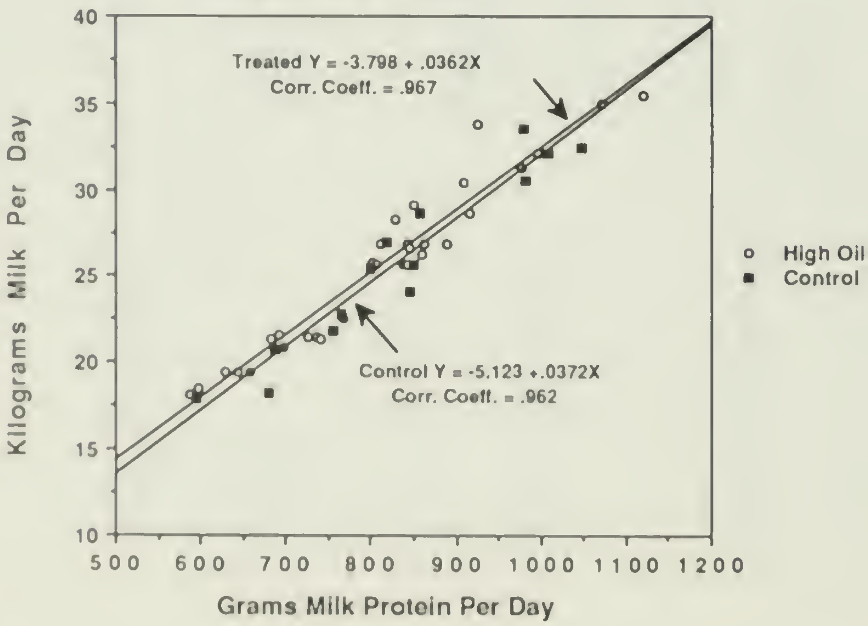


Fig. 5 Relationship Between Intake of Supplemental Fats and Milk Protein Percent

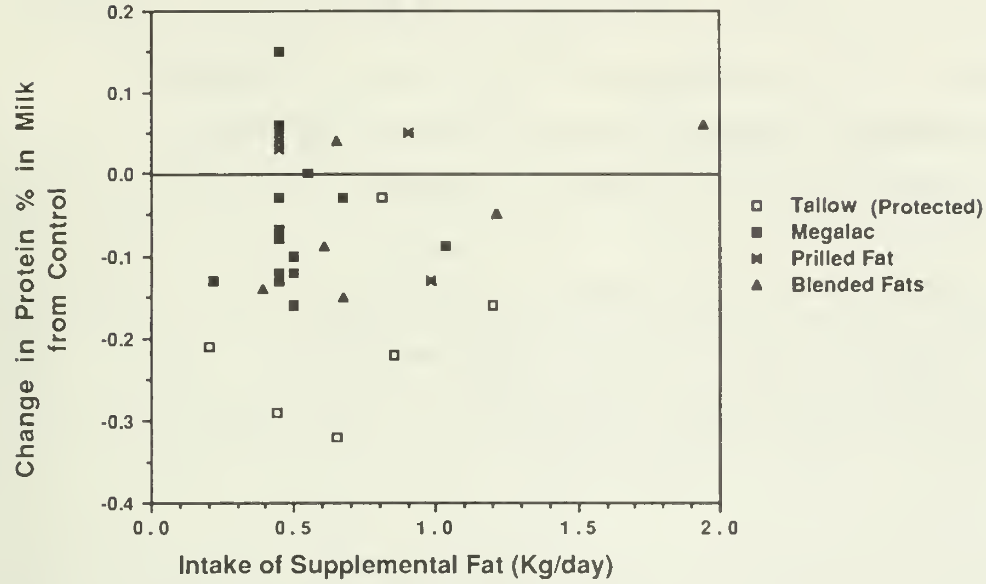


Fig. 6 Effect of Fat Supplementation on Actual Milk Yield

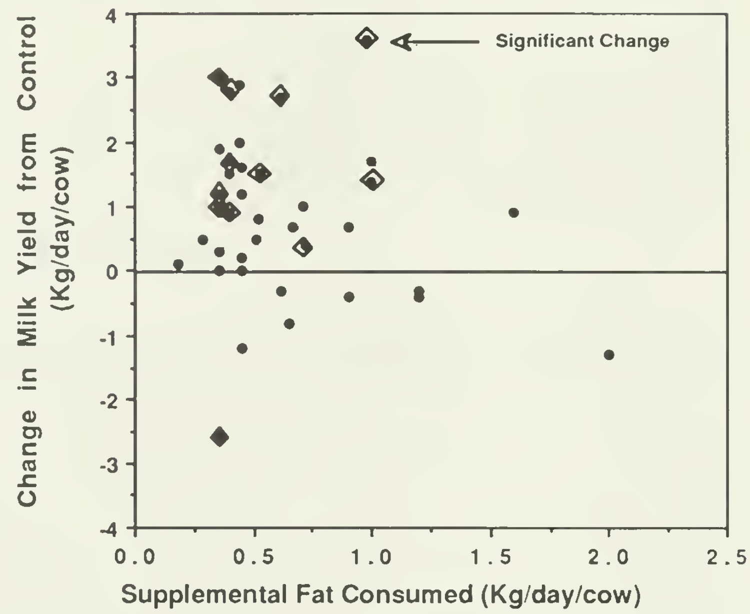
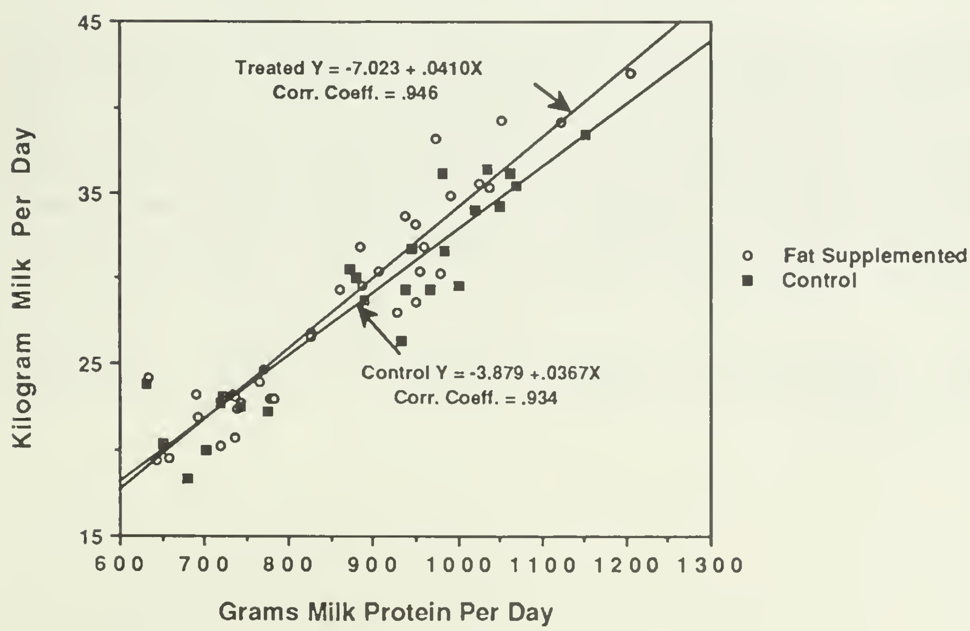


Fig. 7 Effect of Special Fat Supplements on Milk Protein Yield



Effects of Calcium Salts of Long Chain Fatty Acids and Source of Protein on Nutrient Passage to the Small Intestine of Dairy Cows

Tim H. Klusmeyer, Gary L. Lynch, Jimmy H. Clark, and Dale R. Nelson

Rumen microbes can tolerate only about 5 percent unprotected fat in the diet. Feeding excessive amounts of fat and especially fat that contains large amounts of unsaturated fatty acids has been reported to decrease fiber digestibility, the acetate to propionate ratio in rumen fluid, dry matter intake, milk production, and milk fat and milk protein percentages. These problems must be overcome if large amounts of fat are to be used successfully in feeding dairy cows.

Feeding ruminally inert fat and ruminally protected protein offers promise for overcoming these problems. It has been suggested that feeding preformed calcium salts of long chain fatty acids (Ca-LCFA) does not alter ruminal fermentation because of their insolubility, provided the pH of the rumen is maintained above 6.0. Data to determine the effects of feeding Ca-LCFA, fish meal (a highly nondegradable protein source), or both on rumen fermentation and nutrient passage to the small intestine of high producing dairy cows eating large amounts of feed are limited. Therefore, the objective of this research was to investigate the effects of source and amount of energy and protein on rumen fermentation, nutrient passage to the small intestine, and performance of dairy cows.

MATERIALS AND METHODS

Four multiparous Holstein cows surgically fitted with ruminal and duodenal cannulae and averaging 27 days postpartum were used in a 4x4 Latin square with treatments in a 2x2 factorial arrangement (fat x protein). Each period in the square was 14 days with nine days for adjustment to diets and 5 days for data collection. The four dietary treatments were: 1) soybean meal (high ruminal degradability) (SBM), no Ca-LCFA; 2) SBM, Ca-LCFA; 3) fish meal (low ruminal degradability) (FM), no Ca-LCFA; and 4) FM, Ca-LCFA. Ingredient and chemical composition of the diets are shown in Table 1. Soybean meal and FM supplied 14 percent and 17 percent of the protein in FM diets, respectively, and SBM supplied 33 percent of the protein in SBM diets. Diets were fed ad libitum as a total mixed diet, allowing for at least 10 percent refusal.

Chromium oxide was used as a digesta flow marker and purines were used to estimate microbial nitrogen (N) passage to the small intestine. Ruminal and duodenal samples were collected every 3 hours during the last 3 days of each period so that each hour in a 24 hour period was represented. Ruminal bacteria were collected and analyzed 6 times during each period. Feces were collected twice daily during the last 5 days of each period and digestibility coefficients calculated. Milk yield and milk composition were measured during the last 5 days of each period.

Data were statistically analyzed by single degree of freedom orthogonal comparisons for: 1) SBM vs. FM, 2) no Ca-LCFA vs. Ca-LCFA, and 3) the interaction of protein sources and Ca-LCFA.

RESULTS

Intakes, ruminal digestibilities, and apparent total tract digestibilities of organic matter (OM), starch, acid detergent fiber (ADF), and neutral detergent fiber (NDF) were not affected by source of supplemental crude protein (CP) included in the diets (Table 2, 3). Feeding Ca-LCFA did not alter the intakes of OM, ADF, and NDF, but decreased starch intake. The quantity of OM truly digested in the rumen and the quantity of starch, ADF, and NDF apparently digested in the rumen were not affected by feeding Ca-LCFA (Tables 2, 3). Apparent total tract digestibilities of OM and starch were increased (Table 2) and ADF and NDF were not affected (Table 3) when Ca-LCFA were fed to the cows.

Average ruminal fluid pH, concentrations of total volatile fatty acids (VFA) and ammonia, and molar proportions of acetate, propionate, and butyrate were not affected when cows were fed diets supplemented with Ca-LCFA (Table 4). Feeding SBM increased the concentrations of ammonia in ruminal fluid compared to feeding FM, but ruminal fluid pH, concentrations of total VFA, and molar proportions of acetate, propionate, and butyrate were not different when these two sources of supplemental CP were fed to the cows.

Passage of nonammonia nitrogen (NAN), nonammonia nonmicrobial nitrogen (NANMN) and microbial N to the small intestine was not significantly affected by including Ca-LCFA in the diet or by the source of supplemental CP added to the diet (Table 5). When FM was fed, 13 g/day more NANMN passed to the small intestine, but microbial N passage to the small intestine was decreased by 39 g/day and this resulted in a 25 g/day increase in NAN passage to the small intestine when SBM was fed to the cows. Efficiency of microbial protein synthesis and passage to the small intestine, expressed as grams of microbial N per kg of OM apparently or truly digested in the rumen, was not significantly affected by source of supplemental CP but was increased when Ca-LCFA were fed to the cows.

The quantity of individual amino acids that passed to the duodenum was not altered by source of supplemental CP or by feeding Ca-LCFA (Table 6). Feeding FM did not increase individual amino acid passage to the small intestine probably because FM made up a small percentage (17 percent) of the dietary protein. Furthermore, microbial N contributed almost one-half of the NAN passing to the small intestine which had an equalizing effect on the proportions of individual amino acids passing to the small intestine.

Source of supplemental CP or the addition of Ca-LCFA to the diet did not significantly alter production of milk, 4% FCM, fat, protein, or solids-not-fat (Table 7). These data suggest that the Ca-LCFA were inert in the rumen, had little effect on ruminal fermentation, and did not significantly alter nutrient passage to the small intestine. Furthermore, these data suggest that it is difficult to alter the passage of amino acids to the small intestine by feeding recommended amounts of different protein supplements to high producing dairy cows consuming large amounts of feed.

Table 1. Ingredient and chemical composition of diets as a percentage of the dry matter.

Item	Soybean meal: No Ca-LCFA	Soybean meal: Ca-LCFA	Fish meal: No Ca-LCFA	Fish meal: Ca-LCFA
Ingredients				
Alfalfa haylage	30.00	30.00	30.00	30.00
Corn silage	20.00	20.00	20.00	20.00
Ground shelled corn	37.67	33.87	40.05	36.05
Soybean meal (48% CP)	9.32	10.03	3.97	4.30
Fish meal	---	---	3.98	4.31
Dicalcium phosphate	.59	.62	---	---
Limestone	1.00	---	.71	---
Magnesium oxide	.16	.20	.17	.21
Sodium sulfate	.23	.25	.13	.14
Sodium bicarbonate	.75	.75	.75	.75
Salt (plain)	.13	.13	.09	.09
Trace mineral/vitamin mix	.15	.15	.15	.15
Ca-LCFA	---	4.00	---	4.00
Chemical component				
Dry matter	66.2	66.4	66.2	66.4
Organic matter	90.3	90.1	90.6	90.2
Crude protein	17.8	17.8	18.1	18.0
Starch	41.4	37.6	42.2	39.3
Acid detergent fiber	18.5	18.2	18.2	18.0
Neutral detergent fiber	33.3	33.1	33.8	33.0

Table 2. Least squares means for intake and digestibility of organic matter and starch in various segments of the gastrointestinal tract.

Item	Soybean meal: No Ca-LCFA	Soybean meal: Ca-LCFA	Fish meal: No Ca-LCFA	Fish meal: Ca-LCFA	SEM
Dry matter intake, lb/d	55.3	52.4	51.5	49.1	2.6
Organic matter					
Intake, lb/d	50.0	47.1	46.5	44.3	2.4
Apparently digested in rumen, lb/d	15.2	11.7	14.3	10.4	1.7
Truly digested in rumen, lb/d	22.0	18.3	20.3	16.7	2.0
Apparent total tract digestibility, %	69.7	72.2	70.3	72.5	1.1
Starch					
Intake, lb/d	23.3	19.8	21.6	19.6	1.1
Apparently digested in rumen, lb/d	11.5	7.7	9.7	8.1	1.5
Apparent total tract digestibility, %	93.1	95.8	94.1	95.8	.8

Table 3. Least squares means for intake and digestibility of fiber in various segments of the gastrointestinal tract.

Item	Treatments				SEM
	Soybean meal		Fish meal		
	No Ca-LCFA	Ca-LCFA	No Ca-LCFA	Ca-LCFA	
Acid detergent fiber					
Intake, lb/d	10.1	9.7	9.5	8.8	.4
Apparently digested in rumen, lb/d	3.3	2.9	2.9	2.9	.4
Apparent total tract digestibility, %	42.3	45.2	42.8	46.9	2.4
Neutral detergent fiber					
Intake, lb/d	17.8	17.0	16.7	15.4	.7
Apparently digested in rumen, lb/d	6.4	5.2	5.5	4.6	.7
Apparent total tract digestibility, %	47.0	51.0	47.6	50.7	1.9

Table 4. Least squares means for ruminal pH, volatile fatty acids (VFA) and ammonia.

Item	Treatments				SEM
	Soybean meal		Fish meal		
	No Ca-LCFA	Ca-LCFA	No Ca-LCFA	Ca-LCFA	
VFA, mM	128.3	133.1	125.7	122.7	3.5
pH	5.7	5.5	5.7	5.9	.2
Acetate, mol/100 mol	59.3	59.7	60.6	60.8	.7
Propionate, mol/100 mol	27.5	26.5	26.1	25.6	.9
Acetate/Propionate ratio	2.2	2.3	2.4	2.4	.1
Butyrate, mol/100 mol	9.9	10.3	10.0	10.1	.4
Ammonia, mg/dl	12.6	14.2	11.0	12.0	.9

Table 5. Least squares means for intake of nitrogen and passage and digestion of nitrogenous fractions in different segments of the gastrointestinal tract.

Item	Soybean meal, No Ca-LCFA	Soybean meal, Ca-LCFA	Fish meal, No Ca-LCFA	Fish meal, Ca-LCFA	SEM
Intake, g/d	725	680	686	650	31
Flow to the duodenum					
NAN[1], g/d	675	649	627	646	36
NANMN[2], g/d	335	324	343	342	18
Microbial N, g/d	340	325	284	303	21
Microbial N					
g/kg OMAD[3]	53.0	71.2	44.9	76.7	12.8
g/kg OMTD[4]	35.3	41.0	31.3	41.5	3.8

[1]Nonammonia nitrogen.
[2]Nonammonia nonmicrobial nitrogen.
[3]Organic matter apparently digested in the rumen.
[4]Organic matter truly digested in the rumen.

Table 6. Least squares means for passage of amino acids to the duodenum.

Amino Acid	Soybean meal, No Ca-LCFA	Soybean meal, Ca-LCFA	Fish meal, No Ca-LCFA	Fish meal, Ca-LCFA	SEM
	g/d				
Arginine	164	151	149	156	9
Histidine	69	62	61	63	3
Isoleucine	181	166	162	168	11
Leucine	326	295	294	297	19
Lysine	185	164	164	173	9
Methionine	58	51	52	56	4
Phenylalanine	185	170	163	168	10
Threonine	175	163	156	163	11
Valine	217	190	194	199	14

Table 7. Least squares means for milk and milk component yields.

	Treatments				
	Soybean meal		Fish meal		
Item	No Ca-LCFA	Ca-LCFA	No Ca-LCFA	Ca-LCFA	SEM
Milk, lb/d	87.9	87.9	91.9	89.2	2.0
Milk CP, lb/d	2.60	2.51	2.78	2.58	.07
Milk SNF, lb/d	7.00	6.92	7.29	7.00	.13
Milk fat, lb/d	2.60	2.82	2.86	2.84	.09
4% FCM, lb/d	74.0	77.5	79.7	78.4	1.76

Feeding Protected Fat and Niacin to Dairy Cows in Early Lactation

Peter S. Erickson, Mike R. Murphy, and Jimmy H. Clark

Feeding fat to dairy cows has received increased attention from dairy producers, nutritionists, and the feed industry. Fat has 2-1/4 times the caloric value of carbohydrate making it useful for increasing the energy density of the diet. Feeding highly unsaturated fats such as vegetable oils can decrease fiber digestibility. This is because unsaturated fats appear to reduce the activity of fiber digesting microorganisms in the rumen to a greater extent than more saturated fats (like beef tallow).

Recently, protecting fats by a process of binding calcium to saturated and unsaturated long chain fatty acids (Ca-LCFA) was developed. Such fats remain relatively harmless to rumen microorganisms as long as ruminal fluid pH remains above a pH value of 6. This may be accomplished by feeding adequate amounts of acid detergent fiber or a buffer. If the rumen becomes too acidic, the fatty acids will dissociate from the calcium and the negative effects on fiber digestibility described above can occur. As the Ca-LCFA pass into the abomasum, which is very acidic, they will dissociate. The fatty acids can then be absorbed from the small intestine and either provide additional energy for milk production or be incorporated into milk fat by the mammary gland. Supplementing fat to the diet has decreased milk protein content in several experiments.

Niacin has been supplemented to cows in early lactation to help prevent ketosis. In some studies, 6 grams per day of niacin increased performance of cows in early lactation possibly by decreasing subclinical ketosis. Niacin was also shown to increase the protein content of milk in some studies. The purpose of this study was to evaluate the feeding of Ca-LCFA and niacin to dairy cows in early lactation.

MATERIALS AND METHODS

Ten Holstein cows, having at least their second calf, were assigned to one of four treatments: 1) control (C); 2) 12 grams/day niacin (NA); 3) Ca-LCFA (3% of diet dry matter); or 4) a combination of Ca-LCFA and NA (Ca-LCFA + NA) treatment (Table 1). All cows were fed diet C and 5 pounds of alfalfa-grass hay for the first 7 days postcalving and diet C during the second week. Cows were milked twice daily (6:00 A.M. and 5:00 P.M.) and fed at 11:00 A.M. and 6:00 P.M. Feed was offered free choice to provide 10 percent feed refusal. Niacin (6 g) was fed at each feeding in a carrier containing 34 g of soybean meal and 10 g of dried molasses. Cows fed the control diet received only the carrier. Milk production was monitored from day 15 to day 98 postcalving. Milk samples were taken at the Monday P.M. milking and again during the Tuesday A.M. milking each week. Samples were composited by each individual cow's A.M. and P.M. production and analyzed for fat, protein, and solids-not-fat content. Cows were weighed each Wednesday at 8:00 A.M. and body condition of each cow was scored biweekly by two individuals. Between days 56 and 84 post-calving, apparent total tract digestibility of DM, crude protein (CP), neutral detergent fiber (NDF), ADF, and energy were determined.

On day 99 postcalving, cows were again fed the control diet until day 112 to measure any carry-over effects of former treatment. Carrier was not fed during this period.

RESULTS AND DISCUSSION

Crude protein content was similar among diets (Table 2). Acid detergent fiber was also similar among diets, but was less than the 18 percent (DM basis) which was intended. Intake of DM did not differ among treatments indicating that Ca-LCFA did not affect diet acceptability (Table 3). Milk yield was increased in cows fed Ca-LCFA or Ca-LCFA + NA compared to cows not receiving Ca-LCFA. Milk fat content did not differ among treatments. Milk CP content was reduced when cows were fed Ca-LCFA. Niacin supplementation increased milk protein content whether or not Ca-LCFA were fed. Milk protein yield was not altered by feeding fat, suggesting that protein was diluted by increased milk production. Niacin supplementation increased milk protein yield. Body weight change and body condition score were not affected by treatment.

When cows were returned to the control diet (days 99 to 112), milk yield remained elevated and milk protein content remained depressed for cows formerly fed fat (Table 4). However, milk fat content was reduced in cows formerly fed fat. These data suggest that during the treatment period, although milk fat content did not differ, fatty acids from Ca-LCFA were being incorporated directly into milk fat. There were no carry-over effects of niacin.

Digestibility of measured nutrients was not affected by Ca-LCFA or niacin (Table 5); however, when hemicellulose fiber digestibility was estimated (as NDF-ADF), Ca-LCFA improved its digestibility. The significance of this effect has not been established, although others have reported similar results. In conclusion, supplementation of the diet of cows in early lactation with Ca-LCFA improved milk production and addition of niacin increased milk protein content and yield.

Table 1. Ingredient composition as a percentage of dry matter.

Ingredient	Treatments			
	Control	NA	Ca-LCFA	Ca-LCFA + NA
Alfalfa-grass haylage	35.00	35.00	35.00	35.00
Corn silage	10.00	10.00	10.00	10.00
High moisture shelled corn	38.26	38.26	35.49	35.49
Soybean meal	13.50	13.50	14.00	14.00
Limestone	1.30	1.30	.53	.53
Sodium bicarbonate	.75	.75	.75	.75
Dicalcium phosphate	.50	.50	.52	.52
Sodium sulfate	.22	.22	.22	.22
Salt	.20	.20	.20	.20
Magnesium oxide	.12	.12	.12	.12
Trace mineral and vitamin mix	.15	.15	.15	.15
Ca-LCFA	-	-	3.00	3.00

Table 2. Nutrient composition of total mixed diets.

Component	Diets	
	Control	Ca-LCFA
Dry matter, %	70.4	71.0
Crude protein, %	18.6	18.3
Acid Detergent Fiber, %	16.0	15.9
Calcium, %	1.1	1.2
Phosphorus, %	.5	.5
NE_L, (Mcal/lb)[1]	.77	.82

[1]Estimated net energy of lactation (NE_L).

Table 3. Dry matter intake, milk production and composition, and body weight characteristics.

Item	Treatment: Control	NA	Ca-LCFA	Ca-LCFA + NA
DM intake, lb/d	40.8	40.8	38.6	40.1
Milk, lb/d[1]	79.8	80.3	84.2	86.6
Fat, %	3.32	3.32	3.36	3.35
Crude protein, %[2]	2.71	2.84	2.55	2.68
Crude protein, lb/d[3]	2.14	2.27	2.16	2.34
Solids-not-fat, %[4]	7.80	7.91	7.64	7.76
Solids-not-fat, lb/d	6.20	6.37	6.43	6.72
Body weight change, lb/d	.40	.24	-.48	.15
Body score, (1-5)[5]	2.7	2.6	2.7	2.5

[1]Cows fed Ca-LCFA and Ca-LCFA + NA treatments produced more milk than cows fed other treatments (P<.05).
[2]Cows fed Ca-LCFA and Ca-LCFA + NA treatments had a lower CP content in their milk (P<.01) than those not fed Ca-LCFA, and cows fed NA and Ca-LCFA + NA had a higher milk CP content (P<.01) than those not supplemented with niacin.
[3]Cows supplemented with NA (NA, Ca-LCFA + NA) produced more protein than cows not receiving niacin (P<.10).
[4]Cows supplemented with Ca-LCFA (Ca-LCFA, Ca-LCFA + NA) had a lower milk solids content than cows not receiving Ca-LCFA (P<.05).
[5]Body condition score (1=thin, 5=obese).

Table 4. Dry matter intake, milk production and composition, and body weight characteristics after return to the control treatment (days 99 to 112).

Item	Former Treatment			
	Control	NA	Ca-LCFA	Ca-LCFA + NA
DM intake, lb/d	43.2	43.2	44.5	45.6
Milk, lb/d[1]	71.4	71.9	77.8	80.9
Fat, %[2]	3.37	3.34	3.08	2.96
Crude protein, %[3]	2.86	3.01	2.78	2.73
Crude protein, lb/d	2.03	2.16	2.18	2.20
Solids-not-fat, %[4]	7.89	8.03	7.81	7.75
Solids-not-fat, lb/d[5]	5.62	5.76	6.28	6.28
Body score, (1-5)[6]	2.6	2.5	2.6	2.6

[1]Cows formerly supplemented with Ca-LCFA (Ca-LCFA and Ca-LCFA + NA) produced more milk than other cows (P<.05).
[2]Cows formerly supplemented with Ca-LCFA produced milk with a lower fat content than cows fed other treatments (P<.05).
[3]Cows formerly supplemented with Ca-LCFA (Ca-LCFA and Ca-LCFA + NA) had a lower milk CP content than other cows (P<.01).
[4]Cows formerly supplemented with Ca-LCFA (Ca-LCFA and Ca-LCFA + NA) had a lower milk solids-not-fat content than other cows (P<.10).
[5]Cows formerly supplemented with Ca-LCFA (Ca-LCFA and Ca-LCFA + NA) had a higher milk solids yield than other cows (P<.01).
[6]Body condition score (1=thin, 5=obese).

Table 5. Apparent total tract nutrient digestibility.

Measurement	Treatments			
	Control	NA	Ca-LCFA	Ca-LCFA + NA
DM intake, lb/d[1]	45.9	44.5	44.5	42.6
DM digestibility, %	66.4	66.5	67.0	65.8
NDF digestibility, %	59.3	57.2	61.7	60.3
ADF digestibility, %	57.0	56.0	55.8	52.6
Hemicellulose digestibility, %[2]	58.6	57.4	67.5	67.2
Nitrogen digestibility, %	64.3	62.6	66.5	65.8
Energy digestibility, %	63.4	62.7	64.7	62.9

[1]Intake during the period in which digestibility was measured.
[2]Cows fed Ca-LCFA (Ca-LCFA and Ca-LCFA + NA) had improved hemicellulose digestibility compared to other cows (P<.10).

Effects of Source and Amount of Protein on Nutrient Passage to the Small Intestine of Dairy Cows

Tim H. Klusmeyer, Robert D. McCarthy, Jr., Jimmy H. Clark, and Dale R. Nelson

The amount of protein that passes to the small intestine of dairy cows is determined by the amount of dietary protein that escapes ruminal degradation, the quantity of microbial protein that is synthesized and passed from the rumen, and the amount of endogenous secretions and tissues sloughed from the gastrointestinal tract. Feeding proteins like corn gluten meal (CGM) that has a low ruminal degradability has increased the amount of protein that escapes ruminal fermentation in dairy cows. However, associated with this increased escape of dietary protein from the rumen is often a decrease in microbial protein synthesis. Therefore, the objective of this experiment was to investigate the effects of feeding soybean meal (SBM) or CGM in total mixed diets that contained 14.5 percent or 11.0 percent crude protein (CP) on ruminal fermentation, nutrient flow to the small intestine, milk production, and milk composition.

MATERIALS AND METHODS

Four multiparous Holstein cows surgically fitted with ruminal and duodenal cannulae and averaging 139 days postpartum were used in a 4x4 Latin square. Each period in the square was 16 days with nine days for adjustment to diets and 7 days for data collection. Diets were in a 2x2 factorial arrangement within the 4x4 Latin square. The four dietary treatments were: 1) 14.5% CP-SBM; 2) 11.0% CP-SBM; 3) 14.5% CP-CGM; and 4) 11.0% CP-CGM. Ingredient and chemical composition of the diets are shown in Table 1. Diets were formulated to meet the cows nutrient requirements except for the 11.0 percent CP diets which were deficient in CP and all diets were low in acid detergent fiber (ADF). Supplemental CP sources supplied approximately 45% and 22% of the dietary protein in the 14.5% and 11.0% CP diets, respectively. Diets were fed free choice, twice daily, allowing for at least 10 percent refusal.

Chromium oxide was used as a digesta flow marker and purines were used to estimate microbial nitrogen (N) passage to the small intestine. Ruminal and duodenal samples were collected every 3 hours during the last 3 days of each period so that each hour in a 24 hour period was represented. Ruminal bacteria were collected, isolated, and analyzed 6 times during each period. Feces were collected twice daily during the last 5 days of each period and digestibility coefficients were calculated. Milk yield and milk composition were measured during the last 7 days of each period.

Data were statistically analyzed by orthogonal comparisons for: 1) SBM vs. CGM; 2) 14.5 percent vs. 11.0 percent CP; and 3) the interaction between source and amount of CP.

RESULTS

Dry matter (DM), organic matter (OM), and starch intakes were not different between cows fed SBM and CGM (Table 2). Apparent and true ruminal digestibilities of OM, apparent ruminal digestibility of starch, and apparent total tract digestibilities of OM and starch were not different for SBM and CGM based diets. Cows fed CGM consumed .4 pounds/cow/day more ADF and .4

pounds/cow/day less neutral detergent fiber (NDF) than cows fed SBM (Table 3). Ruminal and total tract digestibilities of ADF and NDF were not different when cows were fed SBM and CGM. Intakes and ruminal and total tract digestibilities of DM, OM, ADF, and NDF also were not altered when cows were fed these sources of supplemental CP.

Source of supplemental CP did not alter ruminal fluid pH or the molar percentages of acetate, propionate, and butyrate; however, total VFA concentrations were greater when cows were fed SBM (Table 4). When cows were fed the 11.0 percent CP diets, ruminal fluid pH was increased and concentrations of total VFA were decreased compared to when cows were fed the 14.5 percent CP diets. The average molar percentage of acetate increased and the average molar percentage of propionate decreased resulting in an increased acetate to propionate molar ratio when the 11.0 percent CP diets were fed compared to the 14.5 percent CP diets.

Feeding CGM decreased ruminal fluid ammonia concentrations compared to SBM because CGM is less degradable in the rumen than SBM (Table 4). Feeding diets that contained 14.5 percent CP increased ruminal fluid ammonia concentrations compared to diets that contained 11.0 percent CP because more dietary protein was available for microbial degradation.

Intake of N was greater when cows were fed diets that contained 14.5 percent compared to 11.0 percent CP (Table 5). Feeding 14.5 percent CP diets increased nonammonia nitrogen (NAN) passage to the small intestine compared to feeding 11.0 percent CP diets. Microbial N passage to the duodenum was not altered by the amount of CP in the diet; therefore, the increase in NAN flow to the small intestine was caused by more nonammonia nonmicrobial nitrogen (NANMN) passing to the small intestine in cows fed diets that contained the higher concentration of CP. Intake of N and flows of NAN, NANMN, and microbial N to the small intestine were not affected when SBM and CGM were fed to the cows. The efficiency of microbial protein synthesis and passage to the small intestine, expressed as grams of microbial N/kg of OM apparently or truly digested, was not affected by either source or amount of CP in the diet (Table 5).

Feeding SBM increased the flow of lysine to the small intestine and feeding CGM increased the flows of leucine and phenylalanine to the small intestine, but flows of arginine, histidine, isoleucine, methionine, threonine, and valine were not affected by source of supplemental protein (Table 6). Microbial N contributed between 62 and 81 percent of the NAN that passed to the small intestine when these diets were fed (Table 5) and had an equalizing effect on the relative proportions of individual amino acids that passed to the small intestine.

Feeding the 14.5 percent CP diets increased milk production compared to feeding the 11.0 percent CP diets (Table 7) possible because of the greater passage of amino acids to the small intestine (Table 6). Yields of 4% FCM, milk protein, milk fat, and milk solids-not-fat were greater when cows were fed the higher CP diets. Milk, 4% FCM, and milk fat yields were not affected by source of supplemental protein. However, milk protein and solids-not-fat yields were greater when SBM was fed to the cows compared to CGM. Lysine appeared to be the limiting amino acid in these diets because increased production of milk protein (Table 7) was associated with increased passage of lysine to the small intestine of these cows.

Table 1. Ingredient and chemical composition of diets as a percentage of the dry matter.

Item	Soybean meal 14.5% CP	Soybean meal 11.0% CP	Corn gluten meal 14.5% CP	Corn gluten meal 11.0% CP
	%			
Ingredients				
Corn silage	60.00	60.00	60.00	60.00
Ground shelled corn	24.11	31.46	26.04	32.40
Soybean meal	12.80	4.90	---	---
Corn gluten meal	---	---	10.24	3.87
Salt	.20	.20	.20	.20
Sodium bicarbonate	.60	.60	.60	.60
Trace mineral/vitamin mix	.20	.20	.20	.20
Dicalcium phosphate	.32	.55	.64	.64
Limestone	1.12	1.05	1.04	1.04
Magnesium oxide	.05	.09	.12	.12
Sodium sulfate	.60	.95	.76	.76
Dyna-K	---	---	.16	.16
Chemical component				
Dry matter	53.7	53.7	54.2	53.9
Organic matter	92.8	93.0	93.2	93.0
Crude protein	15.0	11.4	14.5	11.3
Starch	41.5	46.6	45.2	47.6
Acid detergent fiber	16.0	15.9	16.7	16.8
Neutral detergent fiber	38.5	37.1	36.9	36.8

Table 2. Least squares means for intake and digestibility of organic matter and starch in various segments of the gastrointestinal tract.

Item	Soybean meal 14.5%	Soybean meal 11.0%	Corn gluten meal 14.5%	Corn gluten meal 11.0%	SEM
Dry matter intake, lb/d	48.0	46.0	46.0	47.6	1.1
Organic matter					
Intake, lb/d	44.5	43.0	43.0	44.2	1.1
Apparently digested in rumen, lb/d	14.3	12.8	12.6	13.2	1.3
Truly digested in rumen, lb/d	23.3	22.2	21.4	22.7	1.8
Apparent total tract digestibility, %	70.3	68.7	68.8	63.3	2.4
Starch					
Intake, lb/d	20.0	21.6	20.9	22.9	.9
Apparently digested in rumen, lb/d	11.7	11.5	11.0	12.8	1.1
Apparent total tract digestibility, %	95.1	92.8	93.9	91.6	.8

Table 3. Least squares means for intake and digestibility of fiber in various segments of the gastrointestinal tract.

	Treatments				
	Soybean meal		Corn gluten meal		
Item	14.5%	11.0%	14.5%	11.0%	SEM
Acid detergent fiber					
Intake, lb/d	7.5	7.3	7.7	7.9	.2
Apparently digested in rumen, lb/d	.4	.9	2.0	1.3	.7
Apparent total tract digestibility, %	32.7	34.8	37.3	28.2	4.7
Neutral detergent fiber					
Intake, lb/d	18.3	16.7	17.0	17.2	.7
Apparently digested in rumen, lb/d	6.8	5.9	6.6	5.5	.9
Apparent total tract digestibility, %	48.7	46.3	46.2	37.2	4.5

Table 4. Least squares means for ruminal pH, volatile fatty acids (VFA) and ammonia.

	Treatments				
	Soybean meal		Corn gluten meal		
Item	14.5%	11.0%	14.5%	11.0%	SEM
VFA, mM	112.7	98.6	104.5	90.4	3.5
pH	5.89	6.14	5.84	6.14	.21
Acetate, mol/100 mol	57.2	61.4	58.7	59.7	.9
Propionate, mol/100 mol	25.6	21.4	25.3	22.3	1.5
Acetate/propionate ratio	2.3	2.9	2.4	2.8	.2
Butyrate, mol/100 mol	13.4	12.8	12.4	14.0	1.1
Ammonia, mg/dl	10.5	2.5	5.4	1.9	.7

Table 5. Least squares means for intake of nitrogen and passage and digestion of nitrogenous fractions in different segments of the gastrointestinal tract.

	Treatments				
	Soybean meal		Corn gluten meal		
Item	14.5%	11.0%	14.5%	11.0%	SEM
Intake, g/d	524	386	485	394	14
Flow to the duodenum					
NAN[1], g/d	510	424	505	417	18
NANMN[2], g/d	148	80	189	87	37
Microbial N, g/d	361	344	316	330	32
Microbial N					
g/kg OMAD[3]	62.6	77.7	59.3	61.3	11.5
g/kg OMTD[4]	35.4	36.2	32.8	32.5	2.4

[1]Nonammonia nitrogen.
[2]Nonammonia nonmicrobial nitrogen.
[3]Organic matter apparently digested in the rumen.
[4]Organic matter truly digested in the rumen.

Table 6. Least squares means for passage of amino acids to the duodenum.

	Treatments				
	Soybean meal		Corn gluten meal		
Amino Acid	14.5%	11.0%	14.5%	11.0%	SEM
	g/d				
Arginine	121	95	113	94	4
Histidine	59	49	59	51	2
Isoleucine	135	107	134	113	4
Leucine	258	223	324	262	11
Lysine	184	142	155	134	6
Methionine	48	44	54	43	2
Phenylalanine	125	103	140	115	4
Threonine	132	111	126	108	5
Valine	155	124	154	132	5

Table 7. Least squares means for milk and milk component yields.

	Treatments				
	Soybean meal		Corn gluten meal		
Item	14.5%	11.0%	14.5%	11.0%	SEM
Milk, lb/d	64.5	59.3	65.2	58.6	1.3
Milk CP, lb/d	2.14	1.94	1.94	1.74	.02
Milk SNF, lb/d	5.66	5.29	5.57	4.93	.07
Milk fat, lb/d	2.20	2.09	2.27	2.09	.04
4% FCM, lb/d	58.6	55.1	59.9	54.8	.9

Size and Fermentation Effects on Feed Particle Density

Joanne Siciliano-Jones and Michael R. Murphy

Passage of digesta from the rumen is one of the major factors controlling the dry matter intake of dairy cattle in early lactation. Undigested feed and even supplements designed to avoid fermentation by ruminal microorganisms must reach an appropriate size and density (functional specific gravity) before passage from the rumen becomes likely. By studying some of the basic mechanisms involved in this process, it may be possible to identify and then manipulate properties of feedstuffs and supplements which will enable the desired nutritional effect to be achieved.

The passage rate of inert plastic particles from the rumen is maximized at a density of about 1.2. Density of a feed particle in the rumen depends on its chemical composition and the amount of gas and water associated with it. These all change over time due to the dynamic nature of rumen fermentation. It has also been suggested that size affects the density of particles in the rumen.

Our objective was to examine some of the factors which may affect the density of various feedstuffs. In the first experiment, the densities of different particle size fractions were studied with and without gas normally associated with the particles. Our second trial focused on the effects of size and fermentation.

MATERIALS AND METHODS

Trial 1. Feeds used in this trial were: high moisture shelled corn, ground corn gluten feed, corn gluten feed, ground corn-soybean meal concentrate mix, corn silage, alfalfa haylage, alfalfa hay, wheat straw, and sweet clover hay. Feeds were separated into different particle size fractions by dry sieving. Alfalfa hay, wheat straw, and sweet clover hay were ground through a 2 mm screen before fractionation. Feed particle density (without associated gas) was estimated by centrifugation in ethanol-carbon tetrachloride density gradients. The gradients varied from a density of .79 to 1.59 and included glass divers of known density to which the position of feed particles could be compared. Feed particle density (with associated gas) was determined in pyncnometers after the samples had been hydrated in distilled water.

Trial 2. Alfalfa hay, corn silage, grass hay, and wheat straw were studied in this experiment. Hays and straw were ground through 6, 2 or 1 mm screens whereas corn silage was used as fed or dried and ground through a 2 or 1 mm screen. The samples were then fermented for 0, 1, 2, 4, or 8 h in a mixture of strained rumen fluid and artificial saliva. An 8-h blank which contained sample and artificial saliva was included to study the effects of passive hydration. After fermentation, samples were rinsed with cold tap water and density (with associated gas) was determined as previously described.

RESULTS AND DISCUSSION

Trial 1. The densities of all feedstuffs and size fractions were similar after centrifugation had removed gas associated with the particles. Material on the gradients was concentrated in a band with a density of 1.3 to 1.5. Differences were observed when density was measured in hydrated particles with associated gas. Processing corn grain affected its density, although particle size did not. High moisture shelled corn, ground corn gluten feed, corn gluten feed, and corn-soybean meal concentrate mix had average densities of 1.51, 1.45, 1.44, and 1.35, respectively. The densities of forages differed with both type and particle size. They averaged .97, 1.04, 1.20, 1.18, and 1.30 for corn silage, alfalfa haylage, alfalfa hay, wheat straw, and sweet clover hay, respectively. The densities also increased as particle size decreased, confirming work conducted at the University of Vermont. Values for corn silage were variable which reflected the difficulty of obtaining small representative samples of this feedstuff.

Trial 2. Results for the fermentation of feeds ground through various screens are in Table 1. As in Trial 1, forage density increased as particle size decreased. These data support the general concept that large forage particles are less dense because they contain a higher proportion of gas per unit of dry matter than small particles. Differences between forages were not maintained as particle size changed. This interaction is difficult to explain; however, it suggests forages differ in their response to grinding through the same screen.

Fermentation increased the density of feed particles compared to passive hydration for an equal length of time (8 h of fermentation versus 8-h blank). Density also increased with time of fermentation. This effect was similar across forages and has also been reported by others. Within a forage, particle size affected the response to fermentation. The density of larger particles increased with fermentation to a much greater extent than it did for smaller particles.

In summary, the density of material being digested in the rumen appears to be determined by several factors. Feedstuff, particle size, and fermentation all affected density when gas associated with the particles was considered. Once further research has defined these relationships,it may be possible to capitalize on the link between density and digesta passage form the rumen. Optimization of ruminal fermentation and passage is needed to maximize dry matter intake and enable cows in early lactation to obtain sufficient nutrients to support high levels of milk production.

Table 1. Specific gravity of feedstuffs ground through various screens as affected by time of fermentation, Trial 2.

	Alfalfa hay			Corn silage			Grass hay			Wheat straw			
Time	1 mm	2 mm	6 mm	1 mm	2 mm	As fed	1 mm	2 mm	6 mm	1 mm	2 mm	6 mm	SE
0 h	1.29	1.15	.80	1.51	1.12	.92	1.43	1.00	1.00	1.39	1.07	.52	.08
1	1.62	1.21	1.01	1.58	1.50	1.03	1.44	1.22	1.07	1.51	1.21	.78	.08
2	1.51	1.48	1.02	1.48	1.41	.97	1.39	1.31	1.09	1.57	1.29	.72	.08
4	1.45	1.49	1.08	1.65	1.45	1.37	1.41	1.43	1.31	1.33	1.28	.86	.06
8	1.41	1.43	1.07	1.66	1.55	1.28	1.39	1.54	1.45	1.54	1.30	.88	.06
8 blank	1.30	1.40	.89	1.42	1.25	.73	1.34	1.12	1.06	1.27	1.31	.84	.07

Illinois Heifer Hustle Program Report

Dewayne E. Dill and Michael F. Hutjens

The Illinois Heifer Hustle Program is a cooperative field research project involving eight Illinois counties (Bond, Carroll, Clinton, Effingham, Jo Daviess, Stephenson, Washington & Whiteside) and 32 farms. The objectives of this project are 1) to determine the heifer management practices and 2) measure heifer growth on Illinois dairy farms.

The project is divided into 3 phases. During the first phase, wither height, hook height and body weight was to be measured on every heifer and a survey of the heifer management practices on each participating farm was to be completed. During phase 2, each heifer measured in phase 1 was to be remeasured every 4 months until 24 months of age. The final phase involved measuring first lactation milk yield for each heifer. Phase 1, surveying participating farms and initially measuring all heifers was completed in March, 1989. Phase 2 measurements are in progress and will be completed in March, 1991.

Thirty two farms completed heifer management surveys. Survey results are summarized in Table 1. Results of particular interest include: 72 percent fed whole milk while only 16 percent fed soured colostrum; 66 percent used Deccox and 69 percent used Bovatec or Rumensin; 31 percent used estrus synchronization and 52 percent bred heifers according to weight (average weight at breeding was 788 lbs). These survey results illustrate that many dairyman that participated in this project were using recommended heifer management practices.

Table 2 summarizes the grouping of heifers and rations fed each group. The farms surveyed averaged 5 heifer groups. The average age for each group was 2 months - 4 months, 4 months - 7 months, 7 months - 13 months, 11 months - 19 months, and 14 months - 20 months. Heifers were most frequently grouped according to age; however, 2 farms with free stall facilities grouped according to group size. The rations were predominantly hay and grain to younger animals with a switch to haylage and corn silage for older animals.

A graph of initial bodyweight and wither height for all heifers measured is contained in Figure 1. When plotted against the Pennsylvania curves for weight and wither height, the average initial weight for all heifers measured exceeded the average Pennsylvania weight but average wither height only exceeded the Pennsylvania curve for heifers at 4 and 8 months of age. Heifers older than 8 months averaged 1 inch shorter than the Pennsylvania curve.

For the initial measurement, there are different animals in each age group. As subsequent measurements are made on the same animals, the rate of growth for individual animals will be determined.

Table 1. Heifer Hustle survey results.

Question	Average	Range
Calving area		
Maternity pen	84% (26/32)	
With cows	12% (4/32)	
Outside	21% (7/32)	
Age at weaning	52 days	28-70
Liquid diet		
Whole milk	72% (23-32)	
Mastitis milk	47% (15/32)	
Milk replacer	44% (14/32)	
Soured colostrum	16% (5/32)	
Milk replacer		
20% protein	3	
22% protein	11	
% fat	17% (10-22)	
% fiber	0.36% (.05-1.50)	
Brand		
FS Fresh Start	3	
Moormans	3	
Co-op milk	2	
Blain's	1	
Master Mix	1	
Nutrena	1	
Purina 200	1	
Wayne	1	
Calf housing		
Hutch	59% (19/32)	
With cows	3% (1/32)	
Calf barn	44% (14/32)	
Calf starter		
First day offered	6	1-25
Days fed	49 days	4-90
% protein	18	14-34
First day hay offered	23	1-61
Used nasam spray	28% (9/32)	
Nasalgen used most frequently		
Used oral E coli vaccine	25% (8/32)	
Genecol used most frequently		
Inject vitamins ADE	19% (6/32)	
Inject selenium	19% (6/32)	
Inject iron	3% (1/32)	
Used Deccox	66% (21/32)	
Used Bovatec or Rumensin	69% (22/32)	
Bovatec	6	
Rumensin	12	
Both		4

Table 1. Continued.

Question	Average	Range
Dewormed heifers	97% (31/32)	
When		
spring and fall	34% (11/32)	
Product		
Ivomec	26% (8/31)	
Rumatel	16% (5/31)	
Vaccinated for IBR, PI_3, and BVD	88% (28/32)	
Percent heifers bred AI	95% (10-100)	
Percent heifers bred by dairy bull	3% (0-90)	
Percent heifers bred by beef bull	2% (0-33)	
Heat synchronization used	31% (10/32)	
Lutalyse	8	
Estramate	2	
Synchromate	1	
Heat detection aids		
Kamar	28% (9/32)	
Caulking	16% (5/32)	
Tail Paint	9% (3/32)	
Hormone treated heifer	0	
Surgically treated bull	0	
Eyes	12% (4/32)	
Used calving ease bulls	69% (22/32)	
Breeding strategies		
Age	15 months	12-19
Weight	788 lb	700-900
Priority		
Age	35% (11/31)	
Weight	52% (16/31)	
Season	13% (4/31)	

Table 2. Heifer grouping and feeding strategies.

GROUP	AGE RANGE (mo.)	LOOSE HOUSING	FREE STALLS	HAY	HAYLAGE	CORN SILAGE	GRAIN	OTHER
				(lb)				
1	2-4	25	2	4.1	2.0	-	4.8	2.5
2	4-7	24	3	7.5	6.0	7.3	5.4	3.2
3	7-13	21	2	9.6	17.5	20.0	5.2	3.2
4	11-19	18	4	9.1	18.5	22.1	5.4	2.0
5	14-20	13	2	7.9	23.5	18.9	4.6	1.3

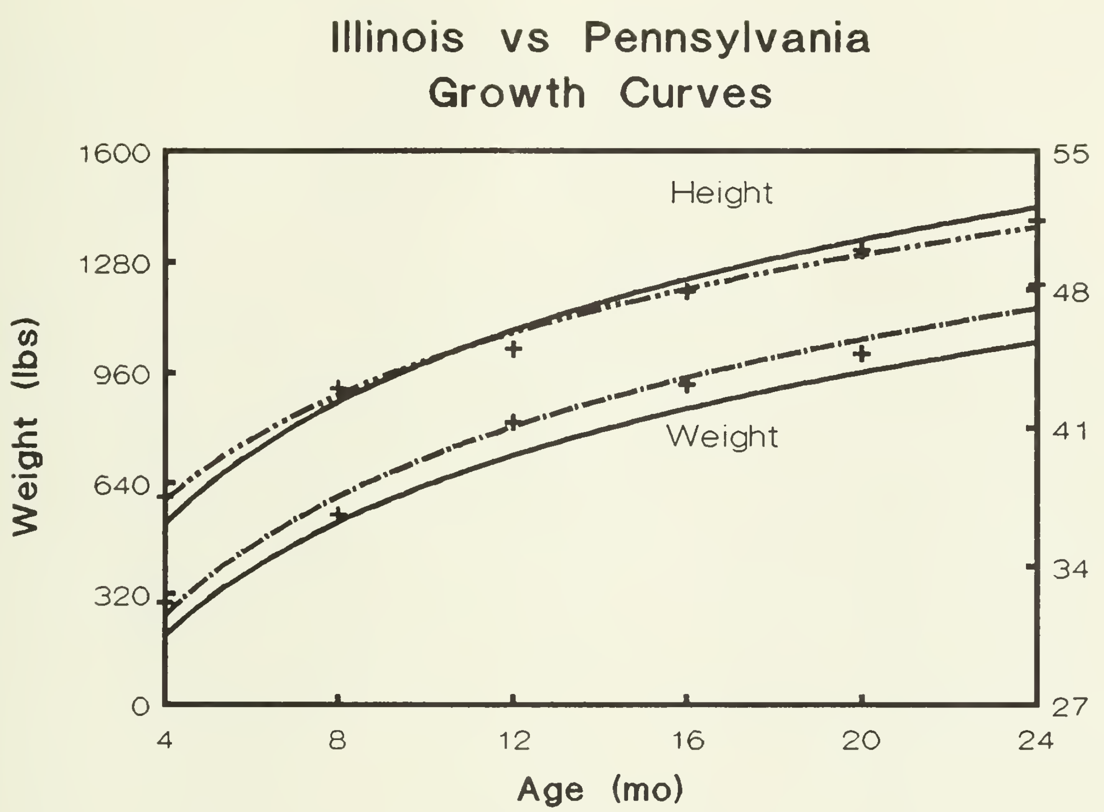


Figure 1. Initial body weight and wither height of heifers 4, 8, 12, 16, 20 and 24 months of age (solid lines are Pennsylvania standards, dashed lines are Illinois field study).